THIRTY-FIFTH ANNUAL REPORT

OF THE

North Carolina Agricultural Experiment Station

1911-1912

THIRTY-FIFTH ANNUAL REPORT

OF THE

NORTH CAROLINA

Agricultural Experiment Station

OF THE

College of Agriculture and Mechanic Arts

FOR THE

YEAR ENDING JUNE 30, 1912

INCLUDING

Scientific and Other Papers and Bulletins

217, 218, 219, 220, 221, 222, 223

WEST RALEIGH, NORTH CAROLINA

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

North Carolina Agricultural Experiment Station,
Office of the Director,

West Raleigh, N. C., June 30, 1912.

To His Excellency, William W. Kitchin,
Governor of North Carolina.

Sir:—I have the honor to submit herewith the report of the operations of the North Carolina Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts for the year ending June 30, 1912.

Trusting that this report will prove satisfactory to your Excellency, I am, Yours very truly,

C. B. Williams,
Director.

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- No. 217. A Serious Lettuce Disease, by F. L. Stevens.
- No. 218. Feeding Experiments with Beef Cattle, by R. S. Curtis.
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THIRTY-FIFTH ANNUAL REPORT

of the Director of the

N. C. AGRICULTURAL EXPERIMENT STATION

for the Year Ending June 30, 1912

By the Director.

During the year the work of the Station has progressed mainly along the lines mentioned in previous reports. Some new lines of investigation have been started and some old ones completed. The nature of the investigations may be gathered from the brief resumé of the work of the different Divisions given below. This is made up from the reports of the heads of Divisions and from the personal observations of the Director.

DIVISION OF AGRONOMY.

The work of this Division has advanced during the year along the same general lines as previously reported; chief attention having been devoted to the corn suckers and soil fertility investigations. In the former investigation an effort is being made to determine the cause of the development of suckers on the corn plant and the relation their production, and prolificacy in ears, sustain to total yield of shelled corn per stalk under different degrees of soil fertility in different seasons. It will also furnish a means by which the correlation between types of corn and different degrees of fertility of the soil will be made and at the same time furnish material for a detailed study of the characters of the corn plant.

For this investigation eight varieties, representing the three common types, viz., one-eared, medium prolific, and very prolific, of dent corn have been chosen. The eight are each planted under seven different conditions of soil fertility, varying approximately from land that will produce ten to eighty or one hundred bushels per acre. The differences are brought about in the land by the use of different quantities of stable manure and commercial fertilizer. In each set there are thirty-two rows, four to each variety, two from which the suckers are removed and two on which they are allowed to grow. By this means a comparison will be obtained that will show the effects of the undisturbed production of suckers upon yield and other characters of the corn plant under different degrees of fertility of the soil. The gradation in the fertility of the soil in the different sets will provide an opportunity for a comparison of the relative productivity of the three general types of dent corn, as represented by the eight varieties included in the studies, when grown under the different degrees of fertility. It has been found generally that the yield of grain and stover per stalk, and hence per acre, has been greater with all varieties where the suckers were allowed to remain than where they were removed at the usual stage of development.

With the same variety, it was found that stalks bearing suckers were somewhat lower than those from which they were removed. A decidedly larger percentage of smutted stalks were found on the more fertile plats, and on the portion of plats with the different varieties on which suckers were allowed to grow. In the test last year Biggs' Seven-ear, the most prolific variety ever tested at the Station, yielded the highest amount of shelled corn per acre, with Cocke's Prolific, Sanders' Improved, Weekley's Improved, Brake's, Hickory King, Wyatt's Improved Yellow and Holt's Strawberry ranking in the order given.

The soil fertility investigations have been continued with cotton and corn along the same general lines as reported in the previous year. During the excessively dry weather of the past summer, cotton responded well to the heavier applications of commercial fertilizers, while corn did not seem to be but little influenced in yield by such applications. Much better results were shown with cotton from the use of lime than with corn. Bacteriological and Chemical studies are being made on some of the plats. The samples are being drawn monthly for these examinations. Results thus far have shown marked differences in the bacterial count of plats of different degrees of productivity. The study of different phosphatic and nitrogenous carriers of plant food with cotton and corn have been continued, particular attention during the year being devoted to acid phosphate, basic slag, finely ground phosphate rock, Peruvian guano, potash manure, solubilized organic nitrogen, beet refuse compound, calcium cyanamid, dried blood, nitrate of soda, sulphate of ammonia and Kanona tankage.

In the study of varieties of different crops, thirty-eight of cotton; eight of corn; seventeen of wheat; twenty-one of oats; twenty-four of cowpeas; seventeen of soy beans; and seven of adsuki beans are being used this year.

Some of the leading varieties for the conditions as represented by the Station farm as shown by the averages of three or more years' trials are: for cotton, Culpepper's Re-improved, Broadwell's Doublejointed, Toole's Prolific, Moss' Improved, King's Improved and Simpkins' Prolific; for corn, Sanders' Improved, Cocke's Prolific and Weekley's Improved; for wheat, Red May, Purple Straw, Leap's Prolific, Currell's Prolific, Golden Chaff, Fultz and Harvest King; for fall sown oats, Virginia Gray, Appler, Bancroft, Red Rust Proof and Burt; and for cowpeas in yield of shelled peas, New Era, Whippirwill, Small Blackeye, Groit, Iron, Blackeye and Black.

Special selection and breeding work is being carried on by this Division with cotton and wheat in an endeavor to secure strains of these crops better suited to our conditions and at the same time that will prove more highly productive than the varieties of these crops now commonly grown. One selection of cotton and two of wheat have been secured which are very promising as shown by this year's results. In the spring of 1911 work was started with cotton in an effort to determine the type of cotton best suited for growing under different degrees of fertility of the soil in the same locality. Also, in this experiment, the different characteristics of the varieties are being studied when grown under different degrees of fertility of the soil, as complete notes are being made throughout the growing and harvesting season by trained observers. It is planned to extent this work to other crops and localities. At present Culpepper's Improved, Russell's Big Boll and King's Improved varieties are being used. Thus far the results indicate that for the most highly fertilized and manured soil Russell's Big Boll is the best yielder of the three, if the season is sufficiently long to mature this variety.

In the study that is being made of the value of kernels of corn taken from different portions of the ear for seed purposes, the results have thus far shown that those from the middle of the ears produced stalks that yielded the heaviest, while those from the tips and butts were the smallest yielders.

Different systems of rotation for cotton and corn farmers are being worked out on the Station farm.

DIVISION OF CHEMISTRY.

Most of the time of the workers of this Diviision has been taken up during the year with work in connection with the soil bacteriology and cottonseed meal investigations which this Division is conducting in coöperation with other Divisions of the Station. Chief attention has, however, been given to the furtherance of the cottonseed meal toxicity work. Rabbits have practically replaced guinea pigs in these investigations in all the detailed work, as the former have been found decidedly most satisfactory. Most of the important results secured with rabbits are checked up with swine. The feeding has been both by natural and forced methods. Many chemical solvents, ferments and digestive fluids such as hydrochloric acid, sulphuric acid, sodium hydroxide, sodium chloride, ammonium citrate, acetic acid, water, ether, chloroform, alcohol, alcohol and acetic acid, alcohol and sodium chloride, yeast, pepsin, pancreatin, and a mixture of pepsin and pancreatin have been employed in the studies on upland and Sea Island cotton seed and meal. The work thus far has shown that whatever the solvent used the extracts have been found to be nontoxic, and the residue toxic, except in the case of forced feeding with rabbits, where an equivalent of eight or ten times the normal feed of meal was administered.

In feeding Sea Island cottonseed and meal to swine in varying daily quantities from 0.7 to 2.2 per cent, their body weight, it killed in every case but one. The results indicate that the seed and meal from Sea Island is just as toxic as that from upland cotton. The meal was found to be much more toxic to young than to older hogs.

Results secured during this and the previous year with rabbits, guinea pigs and hogs have led the investigators to conclude that the toxic prinple of cottonseed meal was not a salt of pyrophosphoric acid as claimed by Crawford.

It has not been found possible to transfer the toxic substance, if such it be, from an animal suffering from cottonseed meal poisoning to a healthy animal. Results secured indicate that cottonseed meal is quite toxic to young calves when they are fed on it.

The first positive results have been secured in the cottonseed meal toxicity investigations during the present year. In previous years all the results were of a negative character. It has been found that an alcoholic solution of caustic soda greatly reduces, if not entirely overcomes the toxicity of cottonseed meal. The more recent results and observations seem to indicate quite strongly that the toxicity of the meal is due to its acid properties.

In the soil bacteriological investigations which this Division has been conducting jointly with the Division of Plant Pathology and Bacteriology, the work during the year has been confined largely along three lines: (1) to determining the ammonifying and the nitrifying efficiency and nitrification inoculating power of soils from two plats in the Soil Fertility series of widely varying productiveness; (2) to a study of the effects of varying substances upon denitrification in the soil and in solution; and (3) to an attempt at isolation and study of the organism concerned in denitrification.

During the year several papers have been prepared by the workers of this Division embodying results secured in the cottonseed meal toxicity and soil bacteriology investigations, and presented at the meeting of a number of scientific societies.

The sugar beet coöperative experiments which this Division is conducting jointly with the Bureau of Plant Industry with farmers of the State are progressing satisfactorily. The results secured during the fall from the beets grown in many of the mountain counties, indicate strongly promise for the counties of Ashe, Henderson, Jackson, and Watauga, as beets grown in these were of good size and contained more than 14 per cent of sugar. This work has been enlarged and is being continued. The work of this Division has been greatly facilitated by removal during the early part of the fiscal year to larger and better equipped quarters on the third floor of Winston Hall.

DIVISION OF ANIMAL HUSBANDRY.

During the year much of the efforts of this Division has been taken up with work involved in the cottonseed meal toxicity investigations which are being conducted jointly by this, the Chemical and the Veterinary Divisions. The policy of previous years of carrying on most of the detailed experiments with rabbits has been continued, but considerable work has had to be done with swine. Following the publication of the observations and results of Crawford with reference to a salt of pyrophosphoric acid being the cause for the toxicity of certain kinds of cottonseed meal, the workers of this, the Chemical and the Veterinary Divisions, planned and started experiments to check up these results. Contrary to the findings of Crawford, it has been found that Sea Island cotton seed and meal are as toxic as is the seed and meal from upland cotton. Sodium pyrophosphate fed to two pigs for 198 days in daily quantities, equivalent to the total amount of phosphoric acid contained in two pounds of cottonseed meal, failed to kill or even to lead to the development of unfavorable symptoms. One of the most striking features of the Sea Island cottonseed meal feeding was the death of the hogs without premonitory symptoms, after being fed for 208 days and then being run for a few moments in an effort to get them on the scales to be weighed.

From the results of the feeding experiments with horses and mules concluded last summer, it is suggested that one of the most practical cottonseed meal rations for farm work stock, weighing on an average of about 1,000 pounds, would be a feed made up of 10 pounds of corn-and-cob meal and 2 pounds of cottonseed meal per day. If the amount of cottonseed meal exceeds 2 pounds per day the animals will likely refuse it after about three months feeding. The beef cattle feeding experiments which were mentioned in the report a year ago were repeated during the past winter. From the results of work of three years it is clear that the feeding of a good grade of steers during the winter months in North Carolina may be made to return some profit to the intelligent feeder. The results this year have demonstrated the superior value of corn silage over cottonseed hulls as a roughage when fed with cottonseed meal. With corn silage as the roughage, profitable gains may be made for a much longer period than with either cottonseed hulls or corn stover. After 80 to 90 days the lot of steers fed cottonseed hulls began to show diminished gains, while those fed corn silage continued in good condition and made substantial daily gains for 165 days. One lot of steers receiving corn silage as the roughage were fed 2.3 pounds of cottonseed meal per day for a 40-day preliminary period, and after that in regular experiment received a daily feed of 9 pounds of meal for 120 days. In the 165 days this lot of steers consumed 1,237 pounds of meal per steer. The results of this year seem to establish the fact that where dry roughages like cottonseed hulls and corn stover are used in connection with cottonseed meal for fattening cattle the period of profitable feeding is much shorter than when a succulent feed like corn silage is used with the meal. The grazing experiments with swine, previously mentioned, are being continued along the same general lines as reported. Such crops as cowpeas, soy beans, rape, Canada field peas and oats are being used. A flock of twenty grade ewes have been added to the equipment of the Division for experimental purposes. During the year the Division has published three bulletins on the feeding and management of beef cattle and one on the feeding, care and management of sheep. The facilities for the workers of this Division have been materially improved during the year by the addition of stock and equipment.

DIVISION OF HORTICULTURE.

During the year the main energies of the workers in this Division have been devoted to work in connection with the investigations that are being conducted on the self-sterility of blackberries, dewberries, and muscadine grapes, and on the transmission of characters in hybrids of the latter. The work on self-sterility of muscadine grapes has been practically completed and the results were published in bulletin 209; that on dewberries and blackberries will probably be finished at the end of the present growing season. Of the twenty-three varieties of blackberries under observation McDonald, Rathbun, Sorshy, May and Spaulding have been found to be self-sterile, the others have been found capable of complete self-fertilization. With dewberries, those varieties of the Southern type (Rubus trivialis) have generally shown to be self-sterile, while those of the Northern type (Rubus villosus) are self-sterile. This year some flowers of three varieties of dewberries and of all the twenty-three varieties of blackberries have been hand pollinated and bagged in continuation of the investigations. The studies of the pollen of self-sterile varieties have been continued and have shown it to be viable in every case, hence self-sterility can not be attributed to impotency of the pollen. As the results with muscadine grapes have shown that all the cultivated varieties studied are unable to bear fruit, unless pollen from a male vine is supplied, they emphasize the importance of having in or near muscadine vineyards male muscadine vines. The pollen of the bearing vine does not seem to be active.

The investigations that have been conducted for some years by this Division as to the nature and cause of double-flower of blackerries and dewberries have been completed and the results published. It was found (1) that the trouble was due to a fungus; (2) that a method of pruning in which all the wood showing above the ground is removed after fruiting is quite effective in keeping the disease in check; and (3) that this treatment followed by a spraying with Bordeaux mixture will practically insure the grower against the ravages of the disease. In the study of the transmission of characters in hybrids of muscadine grapes, several varieties are being used. An effort is being made to determine if such characters as color of berry, persistence of holding fruit and size of fruit clusters are transmittible, and if so what are the laws governing transmission. From the first and second lots of crosses of different varieties, there are now growing in the field and in the greenhouse 3785 seedlings. Numerous new crosses were again made during the past spring. It will be necessary to continue the studies on the resulting hybrids for several years so that their blooming and fruiting habits may be determined. An investigation of the variations of the scuppernong grape propagated asexually is being made.

Some work is being conducted on the self-sterility, self-fertility and the cause of seedlessness in the persimmon, but this work has not advanced sufficiently to make any deductions at this time. The experiments previously mentioned, designed to study the effects of different methods of pruning apple trees have been continued during the year.

DIVISION OF VETERINARY SCIENCE.

During the year the Veterinarian has devoted his energies chiefly to work in connection with the cottonseed meal toxicity investigations which this Division is conducting jointly with the Chemical and Animal Husbandry Divisions. Observations have been made on cattle, swine, rabbits and guinea pigs which were fed cotton seed, cottonseed meal and pyrophosphoric acid. With a calf fed heavily on meal for 275 days before dying, unthrift was noted early in the feeding but he did not develop serious symptoms until about ten days before death. Autopsies on one calf, seven hogs, forty-eight rabbits and fifteen guinea pigs have revealed the following fairly constant lesions: excess of abdominal and pleural fluids; irritation of the mucus membrane of the stomach and intestines; reddening of the lymph nodes; edema of the lungs; and the formation of ante-mortem clots in the heart. Histological examinations are being made on a number of selected sections of affected tissues by a prominent comparative pathologist of the Kansas City Veterinary College. Numerous examinations of domestic animals infested with various verminous parasites have been made by the Veterinarian and remedies recommended. This class of parasits has been found to be quite common in the State among horses, sheep, cattle, swine and dogs. In a single pig long worms, common round worms, thorn headed worms, whip worms, nodular worms, kidney worms, tape worms and muscular trichinosis were found. Some attention has been given by the Division to the improvement of the meat and milk inspection of some of the larger cities of the State. The Veterinarian has recommended that a competent inspector be provided to make ante- and post-mortem examinations, market inspection of meats, and inspection of dairies and milk supplies. Information with reference to meat and milk inspection service has been supplied the authorities of a number of cities of the State. The Veterinarian has prepared a bulletin during the year on "Infectious and Parasite Diseases of Domestic Animals," particularly with reference to those prevalent in North Carolina.

DIVISION OF PLANT PATHOLOGY AND BACTERIOLOGY.

The main work of this Division has been directed along the same general lines as previously reported. In the tobacco wilt investigations which are now being conducted at Creedmoor and at West Raleigh, a further study has been made of the value of different soil disinfectants in overcoming or in reducing this trouble. The effects of soil type, soil acidity and subsoiling with dynamite upon the development of the wilt are being carefully noted from cylinder and field experiments. From rotation trials, it is hoped to determine the longevity of the parasite in the soil causing the disease and at the same time work out a more rational system of rotation for the tobacco farmers of the infected area. Promising strains from crosses of different types of tobacco grown in previous years are being grown and studied. New and promising varieties are included in the work from time to time.

The watermelon wilt experiments that have been previously conducted by the Station in coöperation with the Bureau of Plant Industry at Auburn on wilt infected soil are being continued independently by this Division. Forty-one different selections, twenty-six from Auburn and fifteen from Monetta strains, are embraced in the studies this year. The plants showed a resistance of more than 95 per cent from the planting of last spring. The melons proved to be of good size and of excellent eating qualities, but were found to possess quite a brittle rind which rendered them unsuitable for shipping purposes.

Laboratory studies have been conducted during the year on the two most destructive fungous diseases (sclerotinia libertiana and botrytis vulgaris) of lettuce occurring in the State. In many sections the former of these diseases has caused a loss of fully 70 per cent of the plants. This disease may be recognized from the fact that the leaves suddenly wilt much as though they had been scalded with hot water. In a day or two the whole plant is dead and the leaves fall flat on the ground. Examination of the under-side of such leaves shows them to be covered with a fine, white cotton-like growth. A few days later irregular black bodies, varying in size from a mustard seed to a grain of corn, are found. These three signs enable one to easily recognize the disease. Heretofore this disease has been considered practically incurable, but recent work of this Station seems to indicate that it can be controlled if proper measures are observed, to such an extent as to reduce the loss to a very small percentage of the crop, if not entirely eradicate the disease.

During the past year in the Soil Bacteriological investigations which this Division is conducting jointly with the Chemical Division, denitrification has been studied chiefly, particularly with reference to the bacteria concerned in the phenomenon and the conditions which hinder or facilitate the process. In this work small uniform plats are used for testing the effects of nitrate of soda, sulphate of ammonia and cottonseed meal upon the bacterial processes of the soil. Oats, wheat and millet have been used as the crops. Chemical and bacteriological determinations are being run on the plats at certain intervals during the growing season. The monthly study of the nitrifying and ammonifying activities of the low and high yielding plats in the Soil Fertility plats of the Agronomy Division is being continued with marked differences. The investigations by this Station during the past few years have developed the fact that the nitrifying power of North Carolina soils is much lower than the nitrifying power of soils is usually considered to be. Some attention has also been given during the year to a study of the relative value for fertilizing purposes of ammoniacal and nitrate nitrogen.

In the Apple Disease investigations, European canker, wart or twig tumors and orange rust or cedar rust have engaged most attention. During the spring of 1912 spraying experiments with Irish potatoes were started in one or two different localities in the State to determine the comparative value of various fungicides on the growth and yield of the crops, the best time to make applications, the cost for such treatments and the net returns per acre. It is planned to continue these experiments for four or five years.

Three bulletins have been prepared by the Division during the year, two on "A Serious Lettuce Disease" and one on "A Serious Cotton Disease and How to Handle It."

DIVISION OF ENTOMOLOGY.

The time of the Entomologist has been devoted chiefly to work in connection with corn bill bug investigations. His efforts have been confined largely to a study of one species (S. Callosus), as it is thought that practically all the damage to corn in the State is caused by this one. From the life-history studies carried on in an outdoor wire cage, it is practically certain that one full generation occurs each year and a partial second one may occur, but the records secured indicate that the latter occurs only rarely. From seasonal life history studies it has been learned (1) that the adult beetles pass the winter in corn stalks and elsewhere; (2) that they emerge in the spring and feed on corn, rice or cyperus grass; (3) that they commence laying eggs during the latter part of May; (4) that the eggs, larvæ and pupæ occur all the summer and fall; and (5) that adults are emerging all the year after the first of July. In the outdoor cage the beetles have been found to hibernate mostly in the first inch of soil. The investigations have shown that it required on an average of 6 days for incubation of the eggs, 33 days for the larval stage, and nine days to pupate. Plans have been made for continuing this work this summer in badly infected fields at the Pender Test Farm under field conditions. The results of the studies on two species (S. callosus and S. parvulus) have been embodied in two articles for publication in this Report. These include records on all phases of the beetles; feeding habits and development of the larvæ; formation of pupæ cells and duration of pupal stage; emergence of adult beetles, and habits of adults after maturity. From the results of the investigations that have been carried on, it does not appear that the little grass bill bug (S. parvulus) occurs in this State in sufficiently large numbers at present to be considered a serious pest. Although no direct experiments have been conducted to control the corn bill bug, it is the belief of the Entomologist from observations that winter plowing and a rotation of crops will undoubtedly prove effective against this pest under North Carolina conditions. Considerable work during the latter part of the year has been conducted on the life history of the Gloomy Scale. This insect is a most important enemy to the shade trees of North Carolina, having been reported from all the cities and larger towns of the Piedmont and Coastal Plain sections. It is especially injurious to soft maples, which have been so largely used for shade purposes along our city streets. For this work all the small trees on the College campus are available. The biological studies on two species of melon worms which have been carried on by this Division for the past two years were completed during the early part of the year. The results as secured have been put in shape and published in bulletins and reports of the Station. The web-worm investigations started about three years ago have been suspended temporarily owing to lack of material with which to work.

Some attention has been devoted to a study of cotton leaf worm, corn stalk borer and corn weevils, all of which have been quite numerous in the State during the past year. Particularly so with the corn stalk borer, as in many fields examined more than 60 per cent of the corn stalks were infested with this pest.

DIVISION OF POULTRY HUSBANDRY.

With this Division the efforts of workers have been confined chiefly to work in connection with feeding experiments. During the early part of the year different lots of hens were fed experimentally in two series, one of which was confined in medium sized yards and the other which was allowed range on large lots, in which farm crops were kept growing, as much of the time as possible. The four rations tested under these two conditions were, (1) corn alone; (2) wheat alone; (3) a mixture of two parts of corn and one part of wheat with a dry mash made up of equal parts of corn meal, wheat bran and cottonseed meal; and (4) same as latter, except that a mixture of equal parts of wheat and bone meal was substituted for cottonseed meal. These rations were tested for profitable egg production and for their effects upon the breeding qualities of the fowls. In all cases the fowls in the larger yards which were provided at all times with an abundance of green feed gave better results than did those on the same rations in the small yards during the six months of the experiment. With rations Nos. 1, 2 and 3, the cost of production of eggs was so high that the fowls in the small yards were fed at a loss and those in the larger lots at a very small profit. With ration No. 4 there was a marked reduction in cost over the other lots, and here a fair profit was secured.

The production of eggs was from 20 to 33 per cent less in the larger lots than in the small ones. There can hardly be any doubt that the very dry weather that prevailed during the course of the experiment was not favorable for best results with any of the rations. With some modification the experiments in feeding were continued during the past spring. The hens in pens fed a mixture of four parts of corn meal, four parts of wheat bran and two parts of bone meal have laid the largest number of eggs and have done it at the least cost per dozen for feed. Both of the lots were on green crops, one on Bermuda grass and the other on growing oats. The eggs cost for feed from hens in these 10.8 and 10.6 cents per dozen respectively. It is proposed to continue the experiment through next fall and winter, so that the period of least supply of eggs and high prices may be covered. The pens will be made up of units equally divided between yearlings and pullets. Bulletin on "Profitable Poultry Raising" has been prepared by the Poultryman during the year and issued.

There has been an increased demand upon the time of the head of this Division in the way of correspondence and in demand for lecture work in connection with farmers' institutes, poultry shows, short courses, girls' poultry clubs and other meetings of a public nature.

ADAMS PROJECTS.

The following is a list of Adams projects on which work is being carried on at the present time:

Investigations of lettuce and apple diseases.

Soil nitrification with reference to the bacterium concerned and its isolation.

Relation of geology and chemistry of soils to productivity and fertilizer requirements.

Investigation of the cause of the development of suckers on corn and the relation of their production, and prolificacy in ears, sustain to total yield per stalk under different conditions of soil and season.

Investigations on double-flower of blackberries and dewberries and sterility of blackberries, dewberries and muscadine grapes.

Investigations into the nature of the cause for cottonseed meal feeding resulting disastrously frequently when fed to swine.

Field and laboratory studies of yellow sides.

Biological studies of injurious species of corn bill bug occurring in North Carolina.

Study of the transmission of characters in hybrids of rotundifolia grapes.

A life history study of the Gloomy Scale, Chrysomphalus thnebricosus, Comstock, together with an inquiry into the effectiveness of certain remedies.

BUILDING AND EQUIPMENT.

During the past summer the Chemical Division moved from the first floor of Holladay Hall to the second floor of Winston Hall. By thus doing an increase of almost three times the floor space was secured. Considerable new equipment has been added in the Agronomy and Animal Husbandry Divisions during the year. Because of insufficient water supply at the farm for the stock practically all of last year after the opening of spring a six-inch drilled well was put in. The well is 132 feet deep, 94 feet of which is through rock and has a flow of about 8 to 10 gallons of water per minute. The windmill originally at the Poultry plant has been installed at the farm to supply water to the stock from an open well in case of emergency. The water system has been extended to the superintendent's house, the barn and all the feeding and grazing lots. The contract for a five-roomed cottage for the superintendent of the farm has been let and work is well under way. It is expected that the cottage will be ready for occupancy by July 15 to August 1. Two buildings, one 10x20 feet and one 10x10 feet, haave been built at the Poultry yards. A concrete silo, a concrete hog house and considerable other work of this nature has been done at the farm since the beginning of the year.

BULLETINS.

Bulletins have been prepared and have been issued during the year as follows:

No. 217—A Serious Lettuce Disease, by F. L. Stevens.

No. 218—Feeding Experiments with Beef Cattle, by R. S. Curtis.

No. 219—Feeding and Management of Beef Cattle, by R. S. Curtis.

No. 220—Care and Management of the Dairy Herd, by J. C. McNutt.

No. 221—Profitable Poultry Raising, by J. S. Jeffrey.

No. 222—Cottonseed Meal and Corn Silage Feeding Experiments with Beef Cattle, by R. S. Curtis.

No. 223—Sheep Raising, by R. S. Curtis.

No. 8 (Technical)—A Serious Lettuce Disease and a Method of Control, by Stevens and Hall.

No. 23 (Press)—A Serious Cotton Disease (Anthracnose) and How to Handle It, by F. L. Stevens.

DIVISION OF AGRONOMY.

Below is given a report of the field experiments of the Division of Agronomy for the year ending June 30, 1912:

Corn Suckers Investigations.—This test occupied the same land as last year, but instead of having 59 varieties the number was reduced to eight, each variety being selected with the view of representing a particular type of corn. The test is designed to determine the correlation of the different types with varying conditions of fertility of the soil. The land devoted to the test is divided into seven equal parts with a blank space between each of the sets. In each set there are 32 rows, four of which are planted to each of the seven varieties, this giving 1-20 acre to each variety in each of the seven sets, or a total of 7-20 to the variety. The sets have been treated in such a way as to bring about differences in soil fertility, gradating from set one as the most fertile to set seven as the poorest. The first three sets received heavy applications of stable manure in 1909 and 1910, also heavier application of commercial fertilizer than the others. It was planned to have the soil of the plats range in yielding capacity from 75 to 100 bushels from plat No. 1 down to 8 or 10 bushels per acre for plat No. 7. With a view to determining the effect of removing suckers from the stalks, the first two rows of each variety in all of the seven sets had the suckers removed, giving for each variety in each set 1-40 acre with suckers removed, and an equal acreage with suckers unremoved. Each variety is planted under fourteen different conditions, seven differences in the fertility of the soil, and in each case the variety is grown with and without suckers. The number of suckers which varieties of corn produce seem to be determined principally by the following factors: (1) by the addition of available plant-food to the soil which stimulates the plants to increased growth; (2) by better cultivation, which increases the feeding area of the roots, setting free plant-food and conserving moisture, etc.; (3) by late planting, which causes an abnormally rapid growth; and (4) by the amount of rainfall, suckers being more numerous, other things being equal, in wet than in dry seasons, especially if the rain comes when the corn is from two to four weeks old.

In every set except the first, the yield of shelled corn per acre was greater for the half-plats on which the suckers were left, but on the first set there was scarcely any difference in yield of shelled corn between the half-plat on which the suckers were left and the one from which they were removed. The average weight of stover per acre was much greater with the different varieties of the highly fertilized plats for the half-plats from which the suckers were removed, being almost double the yield in some cases. The ears from the half-plat on which the suckers were left were more in number than were those from the other half-plat, but averaged smaller both in length and diameter. There was quite a marked difference in height of the stalks, with and without suckers, those without suckers being the taller. There was no marked difference in the height of the ears on the stalks of those half-plats from which the suckers were removed and on which they were left. In both cases the number of smutted stalks per plat was directly proportional to the fertility of the soil, the number being higher on the heavily fertilized and manured plats. The average number, however, being much greater on the half-plat on which the suckers were left.

In the variety test with the seven sets, Biggs' seven-ear averaged first in rank in amount of shelled corn per acre, having first place in four sets; Cocke's Prolific ranked second with one first place. The other varieties ranked as follows: Sanders' Improved, third; Brake's and Weekley's Improved tied for fourth place; Hickory King, fifth; Wyatt's Yellow Improved, sixth; and Holt's Strawberry coming last.

In comparison with other varieties, Hickory King proved a better comparative yielder as the soil grew poorer, while Holt's Strawberry showed to be the reverse.

The corn variety and sucker tests were continued in 1912 without change from 1911, except that none of the plats received manure.

Cotton.—As in previous years some difficulty was encountered in securing a new supply of seed of all the varieties for planting, in fact with some of the varieties it was not possible to secure seed. In place of these, new ones were substituted. Thirty-eight varieties were tested out this year. In all 14 new varieties are being tested this year, six of which are field selections from varieties already grown. These were No. 3A for Columbia Long Staple; No. 4 from Toole's Prolific; No. 9A from Smith's Double-header; No. 5A from Cleveland Big Boll; and No. 14 and No. 17 from Culpepper's Improved. With 38 varieties tested, 5A ranked second in the amount of seed cotton produced per acre, Haynie's Queen of Georgia being the leading variety. Six out of the 14 new varieties produced above the average in yield. Cleveland Big Boll is the only variety that has shown any marked evidence of having been improved by selection.

This test will be continued. Some of the old varieties will be discontinued and others will be substituted in their places.

Wheat.—The variety test of wheat has been carried on now through five years (1906-1911) with from ten to seventeen varieties in each test. Last year the test included fourteen varieties which had been previously used, together with three new strains (1A, 2A and 4A), which were grown from selected seed from the plant breeding plats. The seven varieties which ranked highest in yield last year were 1A, Purple Straw; 2A, Currell's Prolific, Red May, Red Wonder and Fultz's Mediterranean in the order given. Purple Straw still holds on as averaging the highest in rank of production of grain per acre. The test will be continued possibly with three or four additions.

Oats.—The work last year with oats was simply a continuation of the oat variety test started in 1907. Red Rust Proof, Appler, Burt, Bancroft and Virginia Gray were first in the order given, producing 32.2, 32, 31.3, 30 and 28.7 bushels per acre, respectively. The next variety in yield fell quite a bit below those mentioned above. The varieties in the order given above matured in 214, 215, 205, 215 and 222 days from the date of planting. Dry weather cut down the yield of the varieties materially, especially the late maturing ones.

In the 1911-1912 test many of the varieties had a poor stand due to the hard winter, the freezes killing out a large per cent of the less hardy varieties.

Cowpeas and Soy Beans.—Variety tests of cowpeas and soy beans have been carried on since 1903 with more or less thoroughness each year. Only in 1909 and 1910 was the work full enough for the results to be of the greatest value. Last year the season was so dry and it was so late before the test could be put in that the test for seed production could not be made. There were 24 varieties of cowpeas, 17 varieties of soy beans and 7 varieties of adsuki beans planted.

Owing to late planting, many of the varieties of cowpeas failed to put on enough fruit to note, so it was decided to cut the entire test for hay. This was done October 21, at which date the following varieties had passed the best hay stage: Red Ripper, Holstein, Small Blackeye, Black, Powell's Early Prolific, Large Blackeye, Brown Coffee, Early Unknown, and Whittle. They had shed a portion of the leaves which, of course, made them weigh somewhat lighter than they would had they been cut a little sooner. The eleven highest producing varieties were as follows: Iron, Groit, Brabham, India, Southdown, Small Black, Whippoorwill, Ayrshire, Clay, Unknown. The India variety was so late in maturing that it did not put on fruit. It held its leaves well and stayed green longer than any other variety. Owing to this characteristic combined with its small stems it is considered as well or better suited for hay than any of the other varieties and is but slightly below the most prolific yield.

The adsuki beans did not make very much growth last year on account of the very dry season. All the varieties matured seed.

FERTILIZER EXPERIMENTS.

Main Plats—The main corn and cotton plats in the soil fertility investigations were continued during the past year, the usual fertilizer application again being supplemented with an application of stable manure at the rate of 7.6 tons per acre. The application of manure which was made December 14-20, 1910, was applied with a manure spreader, special pains being taken to distribute the manure evenly over the entire area.

In general the results gotten last year from this test were in line with the results of the previous year, being slightly more emphasized by the second application of stable manure. The cotton plats responded again to heavy applications of commercial fertilizer, while the corn plats seemed not to be affected materially by these applications. The corn did not show any marked response to an application of lime, either with or without commercial fertilizer. The cotton, however, showed some effect of lime when used alone and a more marked effect when used with fertilizing materials. The most marked feature in the whole test is the remarkably high yield of cotton on the plat receiving Thomas slag and stable manure. This high yield has run for some years with the cotton and is gradually increasing each succeeding year.

The soil fertility investigations will be carried on in the usual manner this year, there being no application of stable manure.

Culture Tests.—Rotation, distance and culture tests are being continued along the same lines as previously mentioned. The distance tests particularly gave very promising results last year.

Phosphate Slag.—The phosphate slag test with cotton was continued on the same land as used last year.

With corn in the phosphate slag test applications of materials carrying potash, nitrogen and phosphoric acid resulted in increased yields, carriers of phosphoric acid giving the best results.

Phosphate Rock.—The tests with finely ground phosphate rock on corn and cotton were continued during the year. With corn the largest yield was obtained from the plat receiving the most nitrogen and phosphate, but the increase in yield did not pay for the cost of the extra application. Potash showed an increase in yield only up to the normal application. The cotton plats, receiving an application of stable manure and of ground phosphate rock, gave a higher yield than did the plats receiving dried blood and phosphate rock. The plat receiving 4,000 pounds of manure and 160 pounds of phosphate rock per acre produced 255 pounds more of seed cotton per acre than did the plat receiving 149 pounds blood and 204 pounds phosphate rock.

Miscellaneous Fertilizer Tests With Corn and Cotton.—This test embraces a field study of the fertilizing value of various new nitrogenous fertilizing materials that have come on the market in recent years. The test includes a study of tankage, of potash manure, of solubilized organic nitrogen, of beet refuse compound and of calcium cyanamid. These were tested in comparison with the better known nitrogenous materials such as dried blood, sulphate of ammonia and nitrate of soda as carriers of nitrogen for plant growth. In the corn test the rank of the materials is shown by the yields of shelled corn per acre as follows in the order given: Calcium cyanamid, nitrate of soda, sulphate of ammonia, potash manure, dried blood, beet refuse compound, and solubilized organic nitrogen. For cotton the rank of the different carriers were nitrate of soda, sulphate of ammonia, calcium cyanamid, blood, tankage, solubilized organic nitrogen, beet refuse compound, and potash manure, in the order mentioned.

Peruvian Guano.—The Peruvian guano test has been continued along the same lines as reported last year. An application of Peruvian guano alone at the rate of 250 pounds per acre gave an increase of 490 pounds of seed cotton per acre over the plat receiving no application of fertilizer; while the plat receiving 500 pounds of Peruvian guano per acre gave an increase of 120 per cent over the plat receiving no fertilizer. The plat to which was added a mixture of 162 pounds of Peruvian guano, 65 pounds nitrate of soda, 35 pounds manure salt and 55 pounds acid phosphate gave the second highest yield, falling below the plat receiving 500 pounds of Peruvian guano only 70 pounds of seed cotton per acre.

Variety-Fertility Tests with Cotton.—This test was begun in 1911 to determine the correlation between soil fertility and types of cotton. It was put on land previously devoted to the variety-distance test of cotton. In this investigation three types of cotton were chosen for the experiment, each type being represented by a well known and distinct variety.

The varieties used were Culpepper's Improved, King's Improved and Russell's Big Boll. Each was planted under three different conditions of soil, the differences being brought about by the addition of different quantities of commercial fertilizer. The land was divided into three sets, giving five rows ($\frac{1}{12}$ acre) to each variety in each of the three sets.

The first set received 200 pounds of cotton fertilizer mixture at time of planting; the second, 400 pounds of the same fertilizer at time of planting, and 100 pounds of same with 50 pounds of nitrate of soda as a side dressing on July 1. The third received 600 pounds of the cotton fertilizer at time of planting, 200 pounds of same on June 15, and 100 pounds of same with 50 pounds of nitrate of soda on July 10. In the first two sets, Culpepper's Improved ranked first with Russell's Big Boll second, while in the third set Russell's Big Boll was first with Culpepper's Improved second. Russell's Big Boll seems to be better suited to a rich soil than to a poor one. The variety-fertility test will be continued with slight modifiication. Sets 2 and 3 had applications of stable manure at the rate of five tons and ten tons per acre respectively on May 11 last.

Planting Various Parts of the Ear.—This experiment is designed to study the effect of continued seed-selection and planting of seed from the various parts of ears of corn upon the yielding power and other characteristics of the resulting progeny. As yet the experiment has not progressed far enough in order to make definite deductions from the results. Thus far seed taken from the middle of the ear has produced stalks that gave the largest field weight, with seed from all the ear coming second, and from the butts third.

PLANT BREEDING.

Seed Selection with Cotton.—This work was begun in 1908 and has been continued as outlined in the last report. The work of each year has met with some degree of success. In 1909 and 1910 some very fine plants were produced from selections and enough seed were secured from six varieties for planting along with the other varieties in the variety test of 1911 and 1912. Out of these selections the one from Cleveland's Big Boll is the only one that has shown any marked increase in production, it showing an increase of 231 pounds per acre over that of the seed of Cleveland's Big Boll, secured from the originator of the variety. In 1911 other promising strains were secured and planted in the 1912 variety test.

Seed Selection with Wheat.—This work is carried on in the same general manner as that with cotton. From the selections of 1909 and 1910 enough seed were secured from three of the strains improved by seed selection to plant in the variety test in 1911 and 1912. These all produced above the average, two taking first and third places in the variety test in yield of grain per acre. The work is being continued both with wheat and with cotton.

C. B. Williams,
Agronomist.

DIVISION OF CHEMISTRY.

I have the honor to submit the following report of the Division of Chemistry for the year ending June 30, 1912.

During the year the Division was engaged in the following studies:

Soil bacteriology in coöperation with the Division of Bacteriology; toxicity of cottonseed meal in coöperation with the Animal Husbandry and Veterinary Divisions; inorganic plant constituents in coöperation with the Agronomy Division; methods for leather analysis in coöperation with the referee of the Association of Official Agricultural Chemists; sugar beet culture in coöperation with the Bureau of Plant Industry of the United States Department of Agriculture; methods of analysis; and miscellaneous work.

SOIL BACTERIOLOGY.

In these studies this Division has made 1,379 determinations during the year, which include:

Nitrogen as ammonium by magnesium oxide method	283
Nitrogen as nitrates, phenol disulphonic acid method	759
Nitrogen as nitrates, Tiemann Schultz method	79
Nitrogen as nitrites, Griess method	258
Total	1,379

In coöperation with the Bacteriological Division it has published the following:

Studies in Soil Bacteriology No. V in the Centralblatt für Bakt. Band 28. Manuscripts for Studies in Soil Bacteriology No. V and No. VI are submitted herewith for publication.

TOXICITY OF COTTON SEED MEAL.

This Division has prepared 59.9 kilograms of cottonseed meal feeds, representing 26 different kinds of feed for Belgian hares. There were used in preparing the feeds 89.9 kilograms of cottonseed meal. The following deteminations were made in connection with this work:

Analysis of 96 samples of urine	190
Complete toxicological analysis for non-volatile organic poisons, of liver of calf	1
Nitrogen in feed	6
Nitrogen in urine	4
Sodium in feed	10
Potassium in feed	10
Albumen	38
Phosphoric acid	18
Viscera of animals distilled	27
Tests for formaldehyde	24
Tests for hydrocyanic acid	11
Tests for hydrogen sulphide	3
Tests for nitrogen	3
Tests for sulphur	3
Determination of acidity of meal	6
Determination of material soluble in hydrochloric acid	2
Determination of water soluble material	2
Determination of chlorine	2

INORGANIC PLANT CONSTITUENTS.

For the Division of Agronomy this Division has made 29 ash and 23 phosphoric acid determinations in samples of cotton plant.

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

This Division has made the following determinations for the Referee on tannin:

Soluble solid determinations	20
Glucose determinations	10
Sugar determinations	32

SUGAR BEET CULTURE.

In the spring of 1911 in coöperation with the Bureau of Plant Industry of the United States Department of Agriculture, this Division distributed samples of sugar beet seeds to 150 farmers residing in 14 counties in Western North Carolina and a few other counties scattered over the State. Eighty samples of beets were taken for analysis during the fall of 1912. Analyses were made by the Bureau of Chemistry of the United States Department of Agriculture. The county of Graham furnished only one sample of beet and it contained less than 10 per cent of sugar. The counties of Buncombe, Caldwell and Madison furnished beets containing between 11 and 12 per cent of sugar; the counties of Mitchell, Swain and Transylvania between 12 and 13 per cent, the county of Avery between 13 and 14 per cent, and the counties of Ashe, Henderson, Jackson and Wautauga, beets containing over 14 per cent of sugar.

During the spring of 1912, 388 packages of sugar beet seeds were distributed in the same manner, and during the fall it is expected that the samples will be analyzed as before. The increasing number of samples distributed shows the interest taken by the residents of the mountainous countries.

During the summer of 1911 this Division was removed from Holladay Hall to Winston Hall, just completed. The removal proved to be a considerable interruption of our work, but our facilities are greatly improved. The conditions are far more satisfactory.

Very respectfully,

W. A. WITHERS,
Chemist Experiment Station.

DIVISION OF ANIMAL HUSBANDRY.

I beg to submit the following report of the Animal Husbandry Division for the fiscal year ending June 30, 1912.

One of the principal lines of work under investigation is the cottonseed meal toxicity project which is being carried on in coöperation with the Chemical and Veterinary Divisions. During the year the animal room has been under the direct charge of the Animal Husbandman. The principal phases of the work pursued have been in conjunction with the Chemical Division. A large number of Belgian hares have been fed on extracts, residues and fractions of cottonseed meal. Large hogs have been used in furthering the work of the project where such was possible. Owing, however, to the necessity of fractional separation of the toxic substance not as much work has been done with large hogs as heretofore. Plans are under way for new phases of work with large hogs to test the findings on the small animals used in the laboratory.

During the year, Bulletin 218 on Feeding Experiments with Beef Cattle has been prepared and issued. The object of the experiment, the results of which are reported in this bulletin, were to determine the difference in the feeding value of corn stover, corn silage and cottonseed hulls when fed with cottonseed meal. The results show quite strikingly the great practical value of using corn silage, either as a whole or part of the roughage ration. The finish and greater value of the steers fed on cottonseed meal and corn silage, either as a whole or part of the ration, attested the value of this feed.

The general feeding and management of beef cattle is discussed in Bulletin 219, which was issued as a companion with Bulletin 218.

Bulletin 222, prepared by the Animal Husbandman during the year, deals with the results obtained in the continuation of the experimental feeding of beef cattle. The results secured show the value of corn silage in the beef steer ration where cottonseed meal forms the sole concentrate.

Bulletin 223 on Sheep Raising has also been prepared and published. Sheep raising is discussed from the standpoint of the practical farmer. Frequent calls for information on this subject made it advisable to publish some practical information in bulletin form for the benefit of those interested in this industry.

An additional flock of grade ewes has been added to the live stock of the Division for the purpose of doing experimental work along this line. The Division is fortunate in having the services of Mr. George Evans, a trained English shepherd, for promoting this phase of live stock work.

Considerable correspondence relating to the breeding, care and management of live stock comes regularly to the office.

Respectfully submitted,

R. S. Curtis,
Animal Husbandman.

DIVISION OF HORTICULTURE.

I have the honor to submit the following report of the work of the Division of Horticulture for the year ending with June 30, 1912.

Since taking charge of the Division on September 1, 1911, the time devoted by the Horticulturist to Station work has been taken up largely with the routine work of the office, and in making plans and arranging facilities for the continuation of the conduct of the experiments in progress. Provision has been made for the systematic filing of data secured and for its preservation. This has been accomplished by selecting a uniform kind of paper, printed with a suitable heading and ruled in a uniform style but in different forms, by which it may be adapted to all classes of data secured in experimental work. It is intended that existing data be transferred and assembled upon this paper and be placed on file where it may be referred to at any time. It is also intended that all data yet to be secured be preserved in the same form. Work on existing records looking towards this end will be taken up as rapidly as time permits. The Horticulturist has taken advantage of two opportunities to visit distant points in the State in order to become better acquainted with existing conditions. The first of these was in connection with the Strawberry Meeting held under the auspices of the Norfolk Southern Railway at Elizabeth City, February 1, and the second, a visit to the Pender County Farm of the State Department of Agriculture, at Willard, March 15. At the latter point the prime object of interest was the training of the Rotundifolia grape.

Mr. L. R. Detjen, Assistant in Horticulture, has the conduct of the investigations directly in charge and has devoted his services entirely to station work. His time had been fully occupied in the greenhouse, in the field, and in the office, in attending to the various plantings connected with his work, and in making observations. The Horticulturist wishes to take advantage of this opportunity to express his appreciation of the work of Mr. Detjen and to commend him for his interest in and fidelity to matters in his care.

I. PRINCIPAL INVESTIGATIONS AND EXPERIMENTS.

The following are the major lines of work which are being conducted at the present time under the provisions of the Adams Act.

A. A study of Self-sterility in Blackberries, Dewberries, and Muscadine Grapes.

This experiment naturally divides itself into two parts as follows:

1. *Muscadine Grapes.*—This part of the experiment was practically closed by the publication in September, 1910, of Bulletin No. 209, on the "Self-sterility of the Scuppernong and Other Muscadine Grapes."

2. *Blackberries and Dewberries.*—It is the purpose of this investigation with these fruits to determine (1) what varieties are self-sterile; (2) the cause of self-sterility; (3) what varieties are the best pollinizers of self-sterile varieties, and (4) whether cross-pollination with self-sterile varieties is better than self-pollination.

The results thus far secured point to the following facts, which were in large part reported last year: (1) that of the 23 varieties of blackberries under observation but four—McDonald, Rathbun, Sorshy May, and Spaulding—are self-sterile; (2) that of the 15 varieties of dewberries, Premo, San Jacinto, Chestnut, Manatee, Rodgers, White, Lime Kiln and Munroe are self-sterile; and Lucretia, Austin, Cox and Ruth are self-fertile; e. g., that practically all varieties derived from Rubus trivialis are self-sterile, while those from Rubus villosus are self-fertile; and (3) that the pollen of the self-sterile varieties of dewberries is effective in fertilizing the flowers of other self-sterile varieties. The observations as to the blackberries have extended over two seasons, and those as to the dewberries, in all but three cases, over three seasons.

The work in progress at present has reference particularly to the determination of the self-sterility or self-fertility of all varieties. To this end all varieties of blackberries are being bagged and self-pollinated to complete the three-year period of observation necessary to the determination of this point. Three varieties of dewberries are also being hand-fertilized to settle the doubt still existing in each case. The third object of this investigation is being carried out by the making of crosses between self-sterile, and between self-sterile and self-fertile varieties. The other two points in this investigation have as yet been untouched. The cause of self-sterility does not lie in the impotency of the pollen in this case as in that of the Muscadine grapes, and further work will be necessary in order to definitely explain the results found to exist in ordinary conditions.

B. A Study of Transmission of Characters in Hybrids of Rotundifolia Grapes.

The purposes of this investigation are as follows: (1) to determine whether the white color of the fruit is a unit character which is transmitted; (2) to ascertain which parent determines the color in the first generation of hybrids; (3) to determine whether the persistent habit of the berries of Flowers Improved is a unit character, and whether it is transmitted to crosses of these types; (4) to determine whether the large fruit cluster of the variety Flowers Improved, and of certain male plants, are unit characters and whether transmissible to crosses; and (5) to determine what variations have occurred in Scuppernong grapes by the use of asexual methods of propagation.

Up to the present time no results of sufficiently definite character to warrant publication have been obtained.

During the year about 1,850 seedlings were planted out in the field and constitute the first lot of hybrids secured from varieties of Muscadine grapes. In September, the second lot of seed secured by crossing will be planted in pots in the green house. Observations upon the individual plants of the first lot will be made during the fall and should furnish some interesting data. Cross-pollination looking toward the production of a third lot of hybrids will be the next work to be taken up.

In order to obtain data as to the blooming and fruiting habits of each lot of these hybrids it will be necessary to carry this work on over a period of at least four years. This means that provision for four areas in which to grow the hybrid plants should be made. At present, the first lot is located in the Horticultural grounds of the College, and the presence of other crops of value, and the absence of other suitable areas having the proper soil for this work, have made it imperative that either a new location be selected for the succeeding three lots of hybrids, or that the second one be planted at half the distance of the first lot and partly on the same land. In any case a new location will be necessary for the third and fourth lots.

II. INVESTIGATIONS SUPPORTED BY HATCH FUNDS.

The minor lines of investigation included in this group are those which are taken up to determine their fitness to be classed as major lines, and those which have sprung from the major lines, but are of minor importance. The following studies have been included in this group:

A. *A Study of the Influence of Plant Food on Pollen.*—This is a project which grew out of the work on self-sterility of grapes. During this year no work has been done on this project because of the absence of greenhouse facilities. It is hoped that such facilities may be secured before another year has passed.

B. *Self-Sterility of Persimmons* is a project which was taken up last year and is expected to yield valuable results. The purpose of this investigation is to determine the identity of self-sterile and self-fertile varieties; the best pollinizers; and to learn the cause of seedlessness in persimmons. A plot of ground in the southeastern corner of the College horticultural grounds has been temporarily set apart for this work, and to it seedlings and varieties have been transplanted. Other varieties have been transferred to it by being grafted on seedlings already in place.

C. *A Study of the Effect of Different Methods of Pruning Apple Trees* is a project on which work was started in February, 1910. This experiment is being carried on in the College apple orchard. The work on it has been continued during the year, and observations are being made.

Before closing this report the Horticulturist wishes to express his high appreciation of your interest and support.

Respectfully submitted,

J. P. Pillsbury,
Horticulturist.

DIVISION OF VETERINARY SCIENCE.

I beg to submit the following report of the Veterinary Division for the fiscal year ending June 30, 1912:

Our work in the problem of determining the cause for ill effects from feeding cottonseed meal has consisted in making observations upon cattle, swine, rabbits and guinea pigs fed upon cottonseed meal, whole and modified.

The observations made were in looking for clinical symptoms in the living animals, the post-mortem lesions in those dying from effects of cottonseed meal and the histological changes in tissues taken from such carcasses.

The Animal Husbandry Division fed some thirty-five head of steers rather heavily upon cottonseed meal from December 1, 1911, to April 5, 1912, on an average about 7.5 pounds per steer for 127 days. No ill effects whatever were observed. A yearling calf weighing at beginning 175 pounds and at the end 247.5 pounds was fed 2.5 pounds daily, making a total of 702 pounds fed from October 6, 1910 to July 9, 1911, when it died. There was no gain in weight after first four or five months.

While showing some unthrift from the start, symptoms of disease were not conspicuous until about ten days before death. Symptoms consisted of not eating heartily, looking rather puny and becoming very weak and docile. There were gritting of teeth, rather noisy breathing and softened fæces.

Nine days before death, respirations were 100, pulse 85, and temperature 103.7 degrees F. Hœmatokrit reading of blood was 38 per cent and hæmoglobin was 80 per cent.

The symptoms in thirteen hogs fed cottonseed and cottonseed meal were observed from only a few minutes to four or five days before death. These consisted of loss of appetite, weakness, unsteady gait, more or less blindness and some difficulty in breathing. The hogs in most cases would finally get down unable to rise and lie there in a more or less comatose condition for a few hours to two or three days before dying.

The principal lesions found on autopsy of the calf consisted of slight excess of serous fluid in both abdominal and thoracic cavities, and considerable irritation of the intestines as indicated by marked injection of their mesenteric and visceral blood vessels. The fourth stomach contained considerable sand and gravel, indicating a depraved appetite. The lymph nodes were not found congested, as frequently reported by ourselves and others in cottonseed poisoning. The liver and kidneys showed some congestion. The lungs showed congestion, hepatization and some œdema. The external blood vessels of the heart were injected; a small thrombus and considerable firmly clotted blood were found within the heart.

The autopsies upon seven hogs dying from the effects of cottonseed meal revealed the following lesions:

5 of the 7 showed excess abdominal fluid;
6 of the 7 showed excess pleural fluid;
6 of the 7 showed irritation of mucous membrane of stomach;
4 of the 7 showed congestion of lymph nodes;
6 of the 7 showed œdema of lungs; and
5 of the 7 showed thrombi (antemortem clots) in heart.

The autopsies upon fifty rabbits revealed the following lesions:

36 of the 50 showed excess of abdominal fluid;
14 of the 50 showed excess of pleural fluid;
46 of the 50 showed some irritation of stomach;
43 of the 50 showed some irritation of intestines;
27 of the 50 showed thrombi (ante-mortem clots) in heart;
10 of the 50 showed œdema of the lungs; and
20 of the 50 showed congestion of the lungs.

In some cases it was evident that the lesions were not due to the effects of the cottonseed meal.

The autopsies upon two guinea pigs revealed the following lesions:

1 of the 2 showed excess of abdominal fluid;
1 of the 2 showed some irritation of mucous membrane of stomach;
2 of the 2 showed injection of mesenteric and visceral blood vessels of intestine.

No histological examination was made of any tissues from animals dying the past year of cottonseed meal poisoning. Examinations were made, however, of tissues preserved from cases collected during the first year's work (1908-1909).

Forty-three examinations of such tissues from swine were made consisting of 9 kidneys, 9 spleens, 7 livers, 7 lungs, 4 aortæ, 6 hearts and 1 voluntary muscle.

Nineteen of the forty-three sections showed nothing noticeable, leaving only 24 showing alterations. Among the 19 showing nothing were 7 spleens, 1 liver, 3 lungs, all 4 aortæ, 3 hearts and the voluntary muscle.

Of the 24 showing microscopical lesions:

4 kidneys showed hyperæmia;
6 livers showed hyperæmia;
2 kidneys showed hemorrhage;
1 heart showed hemorrhage;
4 livers showed hemorrhage;
2 kidneys showed inflammation;
4 lungs showed inflammation;
1 heart showed inflammation;
2 sections showed necrosis;
2 sections showed fatty degeneration;
1 section showed fatty infiltration;
3 sections showed disintegration; and
2 sections showed fragmentation.

Of the kidneys of 2 guinea pigs 1 showed nothing, and the other hyperæmia.

Of the livers of 3 guinea pigs 1 showed nothing, 1 hyperæmia, disintegration and fatty degeneration, and 1 inflammation. The heart of one guinea pig showed nothing.

Manuscript for a bulletin on "Some of the Infectious and Parasitic Diseases of Animals Prevalent in North Carolina" has been prepared. It includes two or three non-infectious diseases possessing some features common to the infections.

Numerous inquiries from farmers and others have been answered as well as laboratory examinations have been made of feeds, body tissues, samples of milk and parasites.

Respectfully submitted,

G. A. Roberts,

Veterinarian.

DIVISION OF PLANT PATHOLOGY AND BACTERIOLOGY.

I submit herewith a report of the Division of Plant Pathology and Bacteriology for the year ending June 30, 1912.

During the fiscal year Dr. F. L. Stevens, who had been in charge of the division since its organization as such, resigned to become Dean of the Agricultural College of Porto Rico. Mr. Guy West Wilson was acting head of the division from January 1 to March 15, when the writer assumed charge. This report is largely on work already in progress at that time.

Plant Pathology.—The studies on a Rhizoctonia disease of buckwheat have been continued.

Several apple diseases have been investigated, particularly a canker caused by Nectria, the disease known as Thelephorose, the orange leaf rust or cedar rust, and the bacterial twig blight. Reports on the first three appear elsewhere in this report.

A general survey of cruciferous crop diseases in the state was made preliminary to a detailed study of such diseases. It seems that Fusarium wilt, bacterial black rot, Phoma wilt, and club rot, are the most serious diseases of such crops.

Granville tobacco wilt investigations have been carried on along the lines already in progress.

The Plant Disease Survey in coöperation with the Bureau of Plant Industry of the U. S. Department of Agriculture, has been continued. Numerous inquiries about the identity and treatment of crop diseases have been answered.

By request, the writer attended a hearing of the Committee on Agriculture of the House of Representatives, in support of an appropriation that would provide for effective search for the chestnut bark disease in North Carolina and other states, in coöperation with the Bureau of Plant Industry.

Breeding for Disease Resistance.—Breeding of watermelons for resistance to Fusarium wilt has been continued, during 1911 in coöperation with the Bureau of Plant Industry of the U. S. Department of Agriculture, and during 1912 by this Division alone. The melons are satisfactorily resistant to the disease, and of excellent quality; but greater toughness of rind must be secured before the melons will be satisfactory for shipping.

Soil Bacteriology (in coöperation with the Division of Chemistry).—Report on phases of this work completed in 1911 are published elsewhere in this report under the authorship of F. L. Stevens and W. A. Withers. The bacteriological side of the work was largely suspended during the winter months. In June it was actively resumed, and Mr. W. F. Pate of the Chemistry Division, was temporarily detailed to assist in it. For the present this work includes chiefly a study of the bacteriological activities in the soils of 18 experimental plots on the Station Farm that have received different fertilizer treatment or have had different crop rotations for a number of years.

Respectfully submitted,

H. R. Fulton,

Plant Pathologist and Bacteriologist.

DIVISION OF ENTOMOLOGY.

I have the honor of transmitting herewith, the report of the Division of Entomology for the fiscal year ending June 30, 1912.

During this time Mr. R. I. Smith was Entomologist from July 1, 1911, to December 15, 1911. The writer assumed active duties on February 1, 1912.

During the past year Mr. Smith devoted practically all of his time to a study of the Corn Bill Bug, *Sphenophorous callosus,* and the Little Grass Bill Bug, *Sphenophorous parvulus.*

The common corn bill-bug, *S. callosus,* which causes practically all the so-called bill-bug injury in the State, has received most attention but the project was so stated as to allow for an investigation of all the related species of Sphenophorus.

Only three other species have been discovered in the course of this work, namely, *S. parvulus, S. venatus,* and *S. cariosus,* and no life history study of the last two mentioned has yet been undertaken. All these, however, are serious pests in some States and they should, as time permits, be given careful attention under this project.

The grass bill-bug, *S. parvulus,* is fairly numerous in the vicinity of West Raleigh, and doubtless in other sections of North Carolina. The record of one fertile female collected May 19, 1911, forms an interesting biological study, for her full egg-laying record was secured for the season, and her progency were secured and reared to the adult beetle stage, while larvæ of the second generation were also reared to maturity but no adult beetles of that generation were secured. The work indicates that a partial second generation usually occurs, but whether or not the numbers are sufficient to be of importance, it is impossible to say at this time. As all the rearing records were carried out with eggs and larvæ from a single female collected May 29, and only one reared specimen laid eggs for a second generation, it does not seem advisable to assert that a second generation is a common occurrence. However, the writer believes this to be the case with *S. parvulus,* and with *S. callosus* also, but in even more exceptional cases.

The life history studies of *S. callosus* are included in the records on all phases of the life history of this insect. This includes the feeding and egg-laying habits of the beetles, feeding habits and development of the larvæ, formation of pupal cells and duration of pupal stage, emergence of adult beetles and the habits of the beetles after maturity.

The time of the present Entomologist since his appointment on February 1, last has been devoted almost exclusively to a consideration of the two Adams Fund Projects,—the Corn Bill Bug and the Gloomy Scale.

More emphasis has been placed upon the study of the Corn Bill Bug in the hope that this project could be closed this year, but new developments seem to make this undesirable. Many details of the life history have been worked out in the field, and these have been found to agree in the main with the details previously ascertained by Mr. Smith in the insectary. In addition to corroborating Mr. Smith's work many new facts regarding the habits of the adults in feeding, mating and egg-laying have been established for the first time.

Some progress has also been made in a study of practical farm methods for the control of this insect. But these will require observations covering a period of several years before they can be fully established.

Marked progress on the Gloomy Scale project was prevented owing to the frequent absences of the Entomologist on the Corn Bill Bug work. The life history of this insect from February to June has been gone over and checked up with our previous knowledge and several new host plants have been added to the list.

Mr. Pool of the Civil Engineering Department of the College has kindly furnished us with a map showing the location of all of the trees on the campus which will be of great service in the study of host plant relations. In addition, the J. Van Lindley Company, Pomona, N. C., and the John A. Young Nursery Company, Greensboro, N. C., have furnished us with several samples of all the varieties of maples grown in North Carolina for shade purposes.

The Entomologist has devoted some time to giving advice for the control of insect enemies of shade trees in cities and towns. As our cities and towns increase in population the problem of growing shade trees becomes increasingly apparent. Frequently the trees are injured to such an extent by electric wires, by sewers and gas mains and by filling and grading that they are especially susceptible to the attacks of insects. During the past year many fine trees in Charlotte, Greensboro, Durham and Raleigh have been either killed outright by the attacks of insects or have been so severely injured as to be worthless for shade purposes. This is a phrase of the entomological work of the State that has received very little attention in the past, but that is demanding more and more attention every year. The most unsatisfactory feature of this work is the fact that the Entomologist is not usually consulted until the tree is practically dead or so near dead that remedial measures would be of no avail. The only possible correction for this state of affairs is the education of our people to a better appreciation of the beauty and utility of shade trees together with a series of publications setting forth the essential facts of the life history and control of the more injurious insect enemies of our shade trees.

NOTES ON INSECTS OF SPECIAL INTEREST.

The Cotton Leaf Worm has been unusually numerous this past fall, resulting in causing considerable alarm among cotton growers, who did not know that the worms can not pass the winter in this State, and, therefore, are not liable to occur again in injuring numbers for several years.

The Corn Stalk Borer has been more numerous and destructive than usual. For the last four years I have observed a gradual increase in the corn stalk borer damage. This year over 60 per cent of the plants were infested in many corn fields. I have never seen a field entirely free from this pest, and it now represents one of our most serious corn pests. The best remedy lies in plowing out and burning the corn stubble during late fall. Next to this, late fall or winter plowing, without burning the stubble, is partially effective. The borers live during the winter in the tip of the tap root and in no other situation, hence the reason for these suggested remedies.

Corn Weevil injury has been reported frequently, seemingly more so than during past seasons. Farmers need to prepare a means for successfully fumigating with carbon bi-sulphide. Many copies of Bulletin 203 have been mailed to farmers who have reported corn weevil injury.

The past spring has afforded the usual number of pests of the crops grown on the farms and in the gardens and orchards of the state, and several insects of local importance have demanded the attention of the Entomologist from time to time. Some of the more important of these are the Native Cabbage Worm, Cabbage Louse, Harlequin Bug, Cutworms, Elm Leaf Beetle and Plum Curculio.

There has been some correspondence which it seemed more advisable to handle from this office than to refer to the State Entomologist's office, although that office now takes care of the bulk of the Entomological correspondence of the State.

Respectfully submitted,

Z. P. METCALF,
Entomologist.

DIVISION OF POULTRY HUSBANDRY.

Herewith I beg to submit a report of the Poultry Division for the year ending June 30, 1912.

Of the proposed experiments it was only possible to carry on those in relation to feeding for egg production.

These experiments were begun January 1 with eight pens of ten females each and are being conducted on the same lines as those of previous years, with the exception that cottonseed meal has been left out of all rations as the experiments of former years seemed to justify the same.

As now fed the rations in addition to 2 parts whole corn, 1 part wheat, fed at night to all units alike, are as follows:

Pens 20 and 26—4 lbs. corn meal; 4 lbs. wheat bran; 4 lbs. ground oats.
Pens 21 and 27—4 lbs. corn meal; 4 lbs. wheat bran; 2 lbs. bone meal.
Pens 22 and 28—4 lbs. corn meal; 4 lbs. wheat bran; 2 lbs. beef scrap.
Pens 23 and 29—4 lbs. corn meal; 4 lbs. wheat bran; 2 lbs. bone meal and 2 lbs. beef scrap.

Pens 20, 21, 22, 23 have for range an ample yard set in Bermuda sod.

Pens 20, 27, 28, 29 have a much larger yard (½ acre each) on which it was intended to keep growing some green crop, such as winter oats until same could be harvested and followed by corn for summer. But owing to the dry weather prevailing during the summer the land could not be broken for corn.

In this way the relative merits were to be tested, of limited range on permanent sod versus much larger range on growing green crops.

To date the egg yield has been as follows:

Limited range.	*Large range on growing crop.*
Pen 20—30 6-12 doz.	Pen 26—27 3-12 doz.
Pen 21—53 9-12 doz	Pen 27—62 doz.
Pen 22—38 2-12 doz.	Pen 28—29 8-12 doz.
Pen 23—48 1-12 doz.	Pen 29—40 8-12 doz.

Duing this time each pen has consumed feed for the value as follows:

Pen 20—$7.47	Pen 23—$8.41	Pen 28—$6.70
Pen 21—$6.70	Pen 26—$7.71	Pen 29—$5.44
Pen 22—$7.10	Pen 27—$8.00	

Reckoning the eggs produced at 25 cents per dozen, the results in profit and loss to date are as follows:

Pen 20—$0.15½ profit.	Pen 26—$0.91 loss.
Pen 21—$6.73 profit.	Pen 27—$7.50 profit.
Pen 22—$2.44 profit.	Pen 28—$0.71 profit.
Pen 23—$3.61 profit.	Pen 29—$4.22 profit.

The pens showing the greatest profits, 21 and 27 had bone meal only as animal food and those showing the second best, 23 and 29, had beef scrap in addition to the bone meal. The third pair, 22 and 28, had scrap alone, while the low pair, 20 and 26, had no animal food.

From the data at hand it might be inferred that beef scrap was not as important an ingredient as is generally conceded and that bone meal may be a cheaper source of animal food supply.

The experiments for the ensuing year have in mind the further study of this matter.

During the past year two double and one single pen open-front houses have been completed.

The past winter being a severe one, the merits of this style of house were put to a severe test and except where the back was not entirely storm proof the stock came through in excellent shape. In two cases where cracks were left at the junction of back and eaves the male birds lost the tips of their combs by freezing.

The interest in thoroughbred poultry throughout the State continues to grow. The demand for eggs for hatching and breeding stock being more than sufficient to take all surplus.

Respectfully submitted,

THOS. H. TAYLOR,

Poultryman.

RECEIPTS AND EXPENSES.

North Carolina Agricultural Experiment Station in Account with the United States Appropriations, 1911-1912.

Dr.

To receipts from the Treasurer of the United States, as per appropriations for the fiscal year ending June 30, 1912, under Acts of Congress, approved March 2, 1887, and March 16, 1906:

Hatch Fund	$15,000.00
Adams Fund	15,000.00

Cr.

	Hatch Fund.	*Adams Fund.*
By salaries	$5,321.58	$11,248.47
Labor	2,689.29	1,241.43
Postage and stationery	467.12	227.60
Freight and express	156.60	65.95
Heat, light and water	79.90	33.79
Chemical supplies	13.47	251.48
Seeds, plants and sundry supplies	670.33	127.07
Fertilizers	1,132.21	217.81
Feeding stuffs	2,245.97	452.38
Library	26.29	134.40
Tools, implements and machinery	721.79	145.97
Furniture and fixtures	90.66	345.62
Scientific apparatus		53.30
Live stock	213.40	76.55
Traveling expenses	396.39	73.95
Contingent	25.00	
Buildings and land	750.00	304.23
Total	$15,000.00	$15,000.00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the North Carolina Experiment Station for the fiscal year ending June 30, 1912; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $30,000, and the corresponding disbursements $30,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Acts of Congress, approved March 2, 1887, and March 16, 1906.

(Signed) W. B. Cooper,
M. B. Stickley,
Auditors.

(Seal.)
Attest: A. F. Bowen, *Custodian.*

SCIENTIFIC AND OTHER PAPERS

ECONOMIC VALUE OF CORN SUCKERS.

By C. B. Williams and W. E. Etheridge.

The removal of suckers from the corn plant soon after their development is quite common with farmers throughout the Southern States. This pactice is largely based upon a widespread notion among corn-growers that if the suckers are allowed to remain they will not only sap the energies of the main plant by taking away from it much needed plant-food, but in return will yield little or no grain and what is produced being of an inferior quality. Many farmers even think that suckers when they yield grain at all bear only a few imperfect kernels on the tassels.

Four years ago the North Carolina Experiment Station began field experiments designed to determine, among other things, if the common belief that the removal of suckers proved beneficial to the crop was true or not. In the studies sixty-eight varieties of corn were used in 1908; sixty-one in 1909; forty-nine in 1910; and eight in 1911. During the first three years each variety was grown, with and without suckers, under four different conditions of soil fertility and of distancing of the hills of corn in the row; and in the last year, the varieties with and without suckers, have been experimented with under seven different degrees of fertility of the soil. The gradation in the productivity of the different sets has been held by the use of stable manure and commercial fertilizers. The results and deductions made use of in this paper are taken from the results of these investigations.

CHIEF FACTORS INFLUENCING THE PRODUCTION OF SUCKERS.

Soil fertility, distance between plants in the row, variety and season are the principal factors influencing the number of suckers produced per plant. Ordinarily, chief controllable of these are soil fertility and variety.

Effect of Soil Fertility.—Under favorable seasonal conditions with a definite number of square feet given to the growth of each plant, the number of suckers developing per plant with the same variety will increase as does the productivity of the soil.

As an average of the results of 1910 with forty-nine varieties, 14.1 times as many suckers developed per acre on land producing 44.8 bushels of shelled corn as were produced where a yield of 12.3 bushels were secured; while in 1911 with eight varieties there were 6.4 times as many where the yield was 35.6 bushels as when 17.5 bushels were produced. Again in 1911, on land producing twice as great yield of shelled corn per acre as other land all the varieties averaged 6.5 times as many hills bearing suckers as did the less productive land.

Effect of Different Distancing of Plants.—It was found in 1908 that when corn was grown in four-foot rows on land producing an average of 28 to 32 bushels of grain per acre that 48 per cent higher proportion of the stalks produced suckers and 73.4 per cent more suckers were developed per acre when the spacing of the plants in the row was 30 inches than when the distance between hills was 20 inches. In 1909 and in 1910 with the average yields running 38 to 39 and 41 to 48 bushels per acre the proportion of sucker-bearing stalks was 15.9 and 110 per cent higher respectively, and the yield of suckers 14.3 and 71.4 per cent more at 30-inch than at 20-inch spacing of the hills in the row. On the poorer land used in the experiments, where the yields ran from 9 to 16 bushels of grain per acre, the proportion of sucker-bearing stalks was higher by 29.8 per cent in 1908, 43.5 per cent in 1909 and 650 per cent in 1910 at 30-inch than at 20-inch spacing; while the percentages increase of suckers on this land for these years were 100, 7.8 and 471 per cent more respectively at 30 inches than at 20 inches between hills in the row.

It should be remembered that as the number of suckers produced is influenced to a considerable extent by the fertility of the soil, the more square feet given to each plant on good soil or the wider the space between hills, the distance between rows remaining the same, the higher the proportion of sucker-bearing hills and the greater the number of suckers may be expected to develop per acre, when the same kind of seed are planted on uniform soil.

Effect of Variety.—The kind of variety plays an important part in determining the number of suckers produced per acre under any given condition. In the results of 1908, of 1910 and of 1911, the prolific varieties produced 300, 130.5 and 25.1 percentages respectively more hills bearing suckers than did the one-eared varieties when the two types in each year were grown under identical conditions. In 1911, Brake's a well known single-eared variety, was exceeded in the production of sucker-bearing hills 54.7 per cent by Biggs' Seven-ear, 64.5 per cent by Sanders' Improved, 52.6 per cent by Weekley's Improved, 32.3 per cent by Cocke's Prolific and 29.7 per cent by Hickory King when all were grown on uniform land. As an average of three years' results, the prolific varieties produced 2.6 times a greater percentage of suckers that bore ears as did the one-eared varieties.

Effect of Season.—Other factors being the same, the more unfavorable the season is for the plants, especially during the early part of the growth of the corn, the smaller will be the number of suckers produced per acre. Under favorable weather conditions during the first half of the growing period with corn planted on fertile land, a large development of suckers will under most Southern conditions take place, and these may in some cases with a very dry July and August depress the yield of grain per acre under what it would be were the suckers taken off at the usual time of removal.

SOME CHARACTERS AFFECTED BY REMOVAL OF SUCKERS.

In these investigations, it has been observed that the removal of suckers from the stalks has had, in most cases, a decided influence upon the different characters of the corn plant which contribute to its economic value, such as prolificacy; size of ears; percentage of grain; yield of grain and of stover per acre, etc.

Effect on Prolificacy.—As only results from two years' work (1909 and 1911) have been obtained in determining the effect of the removal of suckers upon prolificacy in ears, of course definite deductions can not be made. The results thus far secured, however, are quite striking in showing that for a good average season the lessening effect in prolificacy by the removal of suckers.

In 1909 there was an average reduction of 46.3 per cent in the number of ears produced per stalk by the corn on the plat from which suckers were removed under what they were on the corresponding plat where the suckers were allowed to develop; but in 1911 there was a reduction of the average number of ears per stalk by 7.4 per cent by allowing the suckers to remain. It should be remembered, however, that the results of the past year were secured under weather conditions that were abnormal and which were as unfavorable to suckers performing their proper functions as would probably ever occur in this latitude, as the season was favorable during the early part of the growth of the plants for the development of a large number of suckers and later on in the growing season it was very dry and the plants suffered greatly for lack of a sufficient moisture supply. For weeks in July and August the leaves of the plants were rolled. It is natural to suppose that under such adverse conditions that the plants having a large development of suckers would suffer much more than did those from which the suckers were removed, but even with all this disadvantage there was not but 7.4 per cent reduction in the number of ears per stalk. As an average of three years' results (1908, 1909 and 1910) with corn planted in four-foot rows on land averaging in yield 37.7 bushels of grain per acre, 18.1 per cent of the suckers produced ears with the hills 30 inches apart in the row and 9.5 per cent at 20 inches. On land averaging 13.7 bushels, 2.1 per cent of the suckers bore ears at 30 inches and 1.5 per cent at 20 inches. It will be observed from this data that from 6.3 to 8.6 times as great percentage of the suckers bore ears on the good land as on the poor land.

Effect on Size of Ears.—With the exception of the results of 1909, the removal of suckers has tended generally to the production of ears by the main stalk of slightly greater length and of diameter, the average being 3.2 per cent in length and 0.8 per cent in diameter. This would seem to be what would be expected since it was found that with a favorable season the prolificacy was increased by the unmolested development of suckers.

Effect on Yield of Grain.—The weight of evidence thus far is that on an average with the kinds of land used and the types of varieties experimented with there is a slight reduction in the weight of grain per stalk by the removal of suckers. There are many varieties, however, in some or all of the different years that have not conformed to the general average of all the results.

Effect on Percentage of Grain-to-Cob.—For this character, the results of all the tests are in quite marked conformity and present strong evidence that the removal of suckers from the stalks slightly reduces the percentage of grain to cob. On good land, as an average of the results of 1909, of 1910 and of 1911, there was a reduction of 0.47 per cent in the percentage of grain-to-ear by taking off the suckers. To appreciate this average difference, it should be remembered that ordinarily the relation between grain and cob is quite constant, being probably less affected by environment than most other characters of the corn plant. During a favorable season, it has been noticed that there was generally a gradual decline, slight but constant, in the percentage of grain-to-cob as the fertility of the land grew less.

Effect on Stover.—With a few individual varietal exceptions all occurring during the very dry season of 1911, all the experiments have shown on an average without exception that sucker-bearing plants are heavier producers of stover than are plants from which the suckers were pulled in the early stages of their development. As an average of three years' results on the best land where the suckers were chiefly produced, the depression in yield of stover per acre by removal of suckers has been found to be 29.7 per cent; notwithstanding the fact that the growth of the suckers diminished the average height of the stalks 3.9 per cent.

Effect on Combined Value of Grain and Stover.—By assigning a value of 80 cents per bushel for grain and $8.00 per ton for stover, it has been found that, on an average of three years' results on the better grade of land, that there was a diminishing by 17.7 per cent of the combined value of the grain and stover by the removal of suckers from the stalks. Only in one case with the sets in the three years was there a greater value of grain and stover taken together. This occurred in 1910, and may have been due to the greater damage to the sucker-bearing portion inflicted by a severe wind storm occurring during August of that year. However this may be, it is quite striking that, on an average of three years' work with eight to sixty-one varieties in each test, more than one-seventh of the value of the corn crop was sacrificed by the removal of suckers. From these data it would appear that hundreds of thousands of dollars must be lost annually by the farmers of the Southern States in labor and in yield by not allowing suckers to develop to maturity on their corn plants.

ECONOMIC IMPORTANCE OF CORN SILAGE IN SOUTHERN BEEF PRODUCTION.

By R. S. Curtis.

There are three distinct agents which must be active in developing the Southern beef cattle industry. First, the South must have better breeding stock applicable especially to sires or heads of the herd. This improvement is dependent, however, in part on the eradication of the cattle tick. Second, a liberal education is necessary in the fundamentals of live stock feeding as pertaining solely to the proper administration of feed. Third, education of farmers and stockmen regarding the necessity of producing more and better home-grown feeds. It is the latter phase of the subject in part on which the writer hopes to bring out some information concerning the economic importance of corn silage in the Southern beef cattle industry.

While this is not a new topic for discussion, it is one of vital and rapidly increasing interest to every farmer who keeps dairy or beef animals. Ten years ago the latter part of the statement would have received no serious consideration for the sole reason that silage had not been extensively tried in the beef cattle ration and feeders generally were loath to give the matter serious thought. However, high priced land and labor and expensive feed-stuffs have compelled the farmer to get more units of value from his crops. The introduction of corn silage as a maintenance ration for breeding stock and a fattening ration for beef cattle has probably done more toward solving the high cost of feed than any other agent. This is especially true, however, during the winter maintenance period. One of the hardships or apparent losses which every breeder or producer of beef cattle must undergo is the proposition of economically wintering a herd of beef cows for the sole purpose of producing a crop of calves the following spring.

In consideration of the production of young cattle, it is well known even in the best grass sections that the winter season is the period of greatest maintenance cost and the one producing the least increase in the value of the animal. This is because the cheap feeds supplied by good grass pasture of necessity become depleted in growth in the fall season and it is for this reason that a cheaper feed must be supplied and one which will produce an increase in the weight and value of the animal if possible. The old system of keeping cattle through the winter or dormant period on dead corn stalks or cheap ill-cured grass, straw or hay, can not compete with the new system of providing succulent feeds liberally in the ration. Cattle wintered in the former manner will in the majority of cases not only lose in weight, but will also be forced to stop their natural body growth which if ever regained, will be at double the expense of feed and labor. This continuous increase in gain and value is applicable both in breeding and in fattening beef animals.

In the Western feed lots, the question of getting finish has not been a difficult problem when the cattle were handled by experienced feeders because the feeds were available to produce the desired condition and the art of feeding has been mastered. However, even under their conditions, silage now forms a prominent place in the ration. It has brought pasturage effects to non-pasturage periods and has, therefore, brought closer together the producer and the feeder, which it will be instrumental in doing under Southern conditions. At first used most extensively by feeders in supplementing winter maintenance rations, silage has gradually found a permanent place in the finishing ration for beef steers. It has not only materially reduced the cost of winter maintenance but has made possible a conditioning of cattle during this period that will compare favorably with the advantages of summer pasture grasses. A recent experiment at the Pennsylvania Station shows most emphatically the practicability of wintering beef breeding cattle on corn silage, whereas, before the use of dry roughage feeds made the wintering period costly and oftentimes impracticable. This experiment is cited primarily because of its practical bearing on Southern conditions and because of the significant character of the work. Briefly discussed, ten Shorthorn and ten Aberdeen Angus cows were placed in winter quarters on a ration of one pound of cottonseed meal daily and all the corn silage the cows would eat. The average amount of silage consumed was 55 pounds per animal daily. The Shorthorn cows were thin at the start but improved steadily during the winter, gaining a total of 238 pounds in 140 days, or an average of 1.7 pounds daily. The Angus cows were in better flesh and made somewhat less improvement, their gain being 151 pounds in the same period, or an average of 1.1 pounds daily. The silage thus proved to be even more than a maintenance ration when supplemented with one pound of cottonseed meal. This gain would have been not only impossible if the cottonseed meal had been supplemented with a dry roughage feed, but the condition of the cattle in the spring would not have been comparable. The average net cost of keeping each cow was slightly over $8.00, while the average increase in value was $33.00. A significant factor in this work showed that silage fed cattle do not need extra shelter when fed on corn silage, a common belief among some cattle men.

This same method of feeding can be followed as well or better in the South, where cottonseed meal is the chief available concentrate and corn silage of excellent quality can be produced. The stimulus which is being furnished for the production of corn in the South adds strength to the argument for using more of this product in the form of silage. The loss of leaves, the most succulent and nutritious part of corn when cured as fodder, places silage in the lead not only in quantity of feed but from experiments and practice, in efficiency and profit.

Experiments during the past three years at this Station show that one and one-half pounds of corn silage is equal to one pound of cottonseed hulls in feeding value. These experiments were conducted with beef cattle during the winter season, hulls and silage being the only roughages fed during the experimental period. During this time cottonseed hulls have sold from $6.00 to $12.00 per ton while the usual rating on corn silage is $4.00 per ton. Not only is this difference in value markedly apparent, but corn silage is a home-grown product, while cottonseed hulls must be purchased practically at a cash outlay by the farmer. Aside from these differences in cost the use of silage actually increases the efficiency of a breeding animal and the final value of a fattened beef animal. These statements are substantiated, the former by the Pennsylvania Station and the latter by the figures from this Station, showing the average net profits for the three years in steer feeding to be $9.00 per head on the silage fed cattle and $3.85 per head on the hulls fed cattle. In addition to this the silage fed cattle were rated each year from $0.25 to $0.50 per hundred above the dry fed steers, which with the cheaper gains made was responsible for the larger profit.

Another striking fact brought out in these experiments was the effect of corn silage in prolonging the period through which profitable gains can be made. The lot fed cottonseed hulls for roughage made the largest increase in weight during the first two months, but during the third month these cattle dropped to .54 of a pound and in the fourth month to .01 of a pound of gain per day. In all other cases the daily gains were made much more uniformly until the close of the experiment. In every case the silage fed cattle made greater gains during the fourth month than was made during the third month by the lot fed cottonseed hulls as the roughage. The average daily gains of the steers as a whole from the time they were placed on feed until sold was a mere fraction under two pounds per day. The total average gain per steer for the 166 days was 322.6 pounds. It is important to note that during the experimental period the average daily gains made by the lot fed corn silage did not lack materially in making the average daily gain made by the entire number of steers during the total feeding period. The average gain during the experimental period for the cattle fed cottonseed hulls was 1.28 pounds and for the cattle fed corn silage 1.70 pounds. This represents approximately 25 per cent increase in the gain of the silage fed cattle over those fed cottnseed hulls.

Recent experiments at the South Carolina Station designed on the same plan as followed by the writer show that steers fed corn silage as a sole roughage with cottonseed meal made not only larger but cheaper gains, and the cattle took on a better finish than steers fed either corn stover or cottonseed hulls. The cattle fed on corn stover made better gains than the lot fed on cottonseed hulls and at less cost. The cottonseed meal required to make a pound of gain on the steers fed silage was 3.22 pounds; on the stover fed steers 4.57 pounds; and the cottonseed hulls fed steers 4.69 pounds. The most interesting factor is the cost per pound of gain which from a relative standpoint corresponds very closely to the average results obtained by the writer. The silage fed cattle made gains at a cost of 6.4 cents per pound; the stover fed cattle 9.82 cents per pound, and the hulls fed cattle 11.9 cents per pound. The profit on the cattle, including the manure, was for the silage fed cattle, $7.20 per head; for the stover fed cattle, $2.50 per head, and for the hulls fed cattle it was a negligible amount.

The writer believes the South to be especially fortunate in having throughout the Southern States a campaign for more and better corn, and for the extended use of the silo. It is believed that through the wise use of silage, cottonseed meal, our dependable concentrate will be increased by one-quarter of its absolute value and the extra finish obtained on the cattle will under normal conditions bring a profit where oftentimes a loss is sustained.

Upon examination under other conditions it is found that extensive experiments at the Indiana Station have shown conclusively that corn silage in a ration of shelled corn, cottonseed meal and clover hay, gave considerably larger gains, cheaper gains, and a greater profit per steer than cattle fed on any other ration. While the conditions under which these experiments were conducted were entirely different from those in the South, the work furnishes additional evidence of the value of corn silage, whatever the supplementary feeds may be. Workers at various other stations have cited similar facts concerning the use of this product. Contrast with the results previously given, the old system of using high priced and less efficient roughage feeds which with extreme care barely maintained the normal weight of the animal and more often a distinct loss in weight resulted. Such was the result of former management in many cases before the silo became a prominent factor in live-stock feeding.

From the experimental evidence at hand the writer figures that beef breeding cattle can be maintained 25 per cent cheaper on corn silage; and beef feeding cattle may be fattened 15 to 20 per cent cheaper. For the latter the extra finish acquired through the use of silage will be valued ordinarily at 10 to 15 per cent over the animal fed dry roughage. This fact has been established from two viewpoints. First, beef cattle fed on dry roughages during a feeding period of average length will actually make their gains at a considerably higher cost than cattle fed on corn silage alone or in combination with a dry roughage feed. Second, it has been definitely determined that cattle fed liberally on corn silage can consume safely from 20 to 25 per cent more cottonseed meal, which, as expected, will produce a characteristic finish of a higher value than is possible during the shorter feeding period. Cottonseed meal is not only less efficient with a dry roughage, but because of the shorter feeding period necessary when so fed, the feeder is unable to acquire the higher market condition required for top prices.

On the saving and efficiency basis established heretofore by the writer, the cost of winter maintenance for breeding stock would represent a saving to the South in feed based on its market value as follows: On the 12,500,000 breeding animals maintained the annual saving to the South would be $37,500,000. On fattening stock based on a 15 per cent saving in feed and the greater efficiency obtained from the other feeds used, the saving would represent on 5,250,000 fattening animals $23,625,000. The figures relating to breeding stock are based wholly on the financial saving, no consideration being taken of the enhanced value or the ultimately more satisfactory breeding condition maintained in the silage fed animals. Corn silage is an important factor in feeding beef cattle where a large quantity of cottonseed meal is fed daily. In the opinion of the writer this is an important factor, since one of the things needful of correction under Southern conditions is a system of feeding whereby fattening cattle may be placed in a reasonably high market condition. No one factor with the exception of the cattle tick is more largely responsible for the failure to get profitable returns on beef cattle than the appalling lack of fat in cattle sent to the market. Just as long as the South follows a haphazard method in cattle feeding and fails to take advantage of scientific facts easily applicable in practice, just so long will she be compelled to patronize a local beef cattle market where prices seldom if ever reach above a mediocre level. Fat cattle will draw central market operators; lean cattle will keep them at home and force a glut on the small local concerns, which under such conditions becomes a menace to the whole cattle breeding industry.

While it is not possible for every cattle owner to equip himself at once with a silo it is believed that he cannot well delay the erection of such farm equipment. Although in some sections of the country such equipment is not as necessary as in the South, it will under any conditions bring non-pasturage areas, or dormant winter periods nearer to grass than any other farm or commercial feed yet placed on the market.

At first used in the dairy cow ration, silage is now considered largely indispensable by modern beef producers. While it even met with much opposition by the large majority of dairymen at first, it has now become a standard feed in caring for dairy, beef breeding and fattening animals. It has formed a connecting link with pasture grass from fall to spring where beef breeding cattle are maintained. This was originally responsible for its popularity. Its great value is now almost unmeasured in cheapening the cost of winter maintenance and in keeping the body in the natural condition which grass produces in the rapidly growing or fattening animal.

Henry of Wisconsin has, through experiments and far-sighted reasoning, placed silage in the rank which it now holds. It has been stated by him that while corn silage produces a watery carcass soft to the touch, this is considered of special importance where corn forms the main concentrated feed in steer feeding because it not only makes a hard dry carcass, but it burns out the system in the shortest possible time. It may well be said that the same condition will hold where cottonseed meal forms the chief concentrate in the ration. With silage or roots digestion is more nearly normal and the digestive tract will continue to work efficiently for a longer continuous period when silage is fed. This the writer has found to work out in practice in experimental cottonseed meal and corn silage feeding. It was on the basis of these facts which have been determined that the statement was made heretofore that a saving of from 15 to 25 per cent would be effective through the use of silage on breeding and feeding cattle. Whether the desirable results are brought about through active digestion of the other feeds or whether it is the nutritive value of the silage is the point at issue. The writer is of the opinion that it is the former factor which increases the efficiency of the cottonseed meal. It is stated by the authority previously mentioned that the tissues of the body being juicy the whole system should be in like condition to permit of rapid fattening. It is recommended to use silage liberally, especially in the preliminary and early stages of the final fattening period. While it should be continued through most of the fattening period the amount fed should be decreased as the feeding period advances and more dry roughages should be substituted. This is to allow for the firming of the flesh and fat as marketable condition is acquired.

These statements are all entirely in accord with the results obtained at this and the other Stations mentioned. While the writer considers silage of value in any ration for beef cattle it is of special importance in the beef steer ration where the feeding period is to be continued for an excessive length of time when the cottonseed meal would have a tendency to burn out the active agents of digestion. While the increase in the use of corn silage for cattle feeding purposes may be slow broadly speaking, conservative, practical and experimental evidence point to the logic of its use wherever possible. Having its origin in the feeding of dairy cattle it has become a standard feed for all ruminating animals. Because of its meritorious properties for such animals in all stages of life it is firmly believed that silos will continue to be an established equipment on every successful Southern live-stock farm.

NOTES ON THREE LIMB DISEASES OF APPLE.

By Guy West Wilson.

NEW YORK CANKER.

History.—This disease first attracted attention in 1898 in the apple districts of New York, hence the name given above. More recently it has come to be known as the black rot canker in recognition of the identity of the fungus with that causing the black rot of the fruit.

Probably the New York canker was a serious apple pest for many years before its detection, but owing to the superficial resemblance of its cankers to those of sun scald the latter trouble was credited with all the damage.

Cause.—The New York canker is caused by a fungus known to botanists as *Sphaeropsis malorum,* Peck. This fungus is one of the more serious apple diseases of America, attacking all the above-ground parts of the tree, causing cankers on the trunk and branches, spotting of the leaves, and causing the black rot of the fruit.

Distribution.—As a fruit rot this fungus is known throughout North America east of the Rocky Mountains on the apple, pear and quince; while as a canker it occurs on all of these trees as well as on the hawthorn or red haw, and probably on other trees and shrubs as well. It also causes a leaf-spot of the apple and probably of the pear and quince. The fungus has recently been found in France, this being its first appearance abroad.

Symptoms.—This canker may attack any part of the tree, but it is most conspicuous on the larger limbs and even the trunks of mature trees. On the other hand twigs are often attacked (Fig. 1), and the young nursery stock may be killed. The cankers vary somewhat in appearance, due to the position upon the tree and the depth to which the fungus has penetrated. If only the twigs are affected the tips die and become covered with the black pustules which are characteristic of the disease. If the larger branches are attacked and the fungus penetrates only into the bark, the diseased area assumes a swollen appearance, and the bark becomes somewhat roughened. Such areas are of little consequence and do slight damage to the tree since the fungus soon dies.

In severe cases true cankers are formed. These may be only a few inches in extent, or they may be several feet long, involving one side of a branch, or in extreme cases completely encircling it. The bark is first thickened and roughened and eventually killed, and a subsequent shriveling and cracking of the bark results in a depressed area on which appear numerous characteristic small black pustules, which are the spore-producing bodies of the fungus. The growing region of the tree, or cambium layer as it is called, is infected and killed so that the canker affects not only the bark but the wood as well. In time the dead bark may break away leaving the wood exposed.

If a branch is completely girdled it of course dies, but if only one side is affected it may live for several years and continue to bear fruit.

However, its vitality is weakened and its productiveness lessened. The exposed wood turns blackish and is conspicuous from a distance; and such a canker gives wood decaying fungi a good place to find lodgment and complete the work of destruction.

It has been proven by experiments that at least under certain conditions this fungus has the power of entering healthy apple bark and causing a disease of otherwise healthy trees. The first attack is usually in the spring and is shown by discolored areas of bark which enlarge till midsummer, when there is formed a definite line of separation between the healthy and diseased bark. Later spore-bearing pustules are formed. The fungus frequently lives in the bark over winter and resumes growth the next season.

FIG. 1.—New York Canker on apple twigs, showing minute pustules of the fungus over the deadened bark. Slightly reduced.

Far more serious than the power of penetrating the bark is the development of this fungus as a wound parasite. While the fungus is able to penetrate the outer layers of bark, the inner layers seem to resist its attacks and prevent its reaching the cambium layer, in which event the deep cankers are not formed. If some other agency first breaks the bark the fungus gains entrance through the wound to the cambium and wood and an extensive canker is developed. Frequently several cankers appear close together, but each has developed from a separate infection as the mycelium does not travel through the wood.

Resistant Varieties.—That certain varieties are much more resistant to the disease than others is well known, yet most of the available lists of varieties and the effects of the disease are made from data obtained in more northern states. The list usually given shows that Spitzenburg and Twenty Ounce suffer most, being almost destroyed in places, while Baldwin, Wagener, Rhode Island Greening and King follow in the order of severity of attack, the worst diseased first. Tallmon Sweet is said to be practically free from attack. Some of these varieties are unsuited to our climate while others are valuable varieties.

Treatment.—Prune out all diseased wood, cutting somewhat below the dead portions to insure the removal of all the infected part. Make all cuts neat and smooth, always cutting a branch off in such way as to leave no projecting stub. Collect and promptly burn all wood cut from trees. Avoid unnecessary wounding of trees by farm implements in cultivation or by ladders or shoes in harvesting. Treat all wounds to prevent access of fungous spores and to promote healing. This will mean smoothing off the surface of the wound and removing any dead or decaying wood or bark so that a clean-cut, sound edge is left for healing. Next wash the surface with a good antiseptic substance, such as a weak solution of corrosive sublimate, or Bordeaux mixture, or lime-sulphur mixture. This should be followed on larger wounds by some permanent covering such as pure thick paint without drier.

Since black rot attacks leaves and fruit, its control will also depend on care of these. Diseased fruits should not be allowed to accumulate on the ground. In off years as well as in bearing years the foliage should be protected by spraying with lime-sulphur, 1 1-2 gallons to 50 gallons of water, just before the blossoms open and just after the petals fall; and with 3-4-50 Bordeaux mixture three weeks later. Trunks, limbs and twigs should be coated as much as possible in the earlier applications; and a winter application of lime-sulphur, one gallon to ten gallons of water, will be of further advantage in protecting these parts.

EUROPEAN CANKER.

History.—As indicated by its name this disease obtained prominence in Europe long before it made its appearance in America. About the year 1900, this canker began to attract attention in New York and Nova Scotia, and since that time it has appeared more or less frequently in different parts of the United States as an apple disease.

Cause.—This canker is caused by a fungus quite different from that of the New York canker, known botanically as *Nectria ditissima*, Tul. (*Nectria coccinea* [Pers.] Fr.) This fungus attacks a wide range of trees and shrubs, including beech, oak, hazel, ash, hornbeam, ironwood, maple, linden, dogwood, magnolia, cherry, gooseberry and others; and it lives as a saprophyte on almost any kind of dead deciduous wood.

Distribution—In America this fungus ranges from Canada southward, throughout the United States. As an apple disease it has gained most prominence in the apple regions of New York, New England, Eastern Canada and on the Pacific Coast. Recently a disease similar to, if not identical with this, has appeared in a serious form in North Carolina. The first report of this disease came from Lincoln County in the fall of 1909 and later it was reported from Sampson and Burke counties, indicating a wide distribution in the State.

Symptoms.—In all cases that have come to the notice of the writer a whitish or pinkish, weblike growth has appeared on some branches of the affected trees. This may or may not be connected with the cankers which develop upon the tree. Its habit of growth is somewhat like Hypochnose (See Bulletin 206 p. 90 of this Station), but the disease is quite a different one.

The canker of this disease may appear on either the trunk or larger branches of the trees, apparently never on the smaller twigs. At first

Fig. 2.—Fruiting bodies of the European Canker. Enlarged about twice.

the bark shrivels and turns grayish, assuming the appearance of being in a drying condition. This becomes most conspicuous in the late summer or in early fall. By spring the outer bark cracks and breaks away, more or less exposing the yellowish brown inner bark, which is covered rather sparingly with small pinkish pustules (Fig. 2), where the spores of the fungus are borne. These spore-bearing bodies average about one-twelfth of an inch in length, but may be either longer or shorter.

After the formation of spores the bark continues to crack deeper and fall away, leaving the wood exposed. The fungus lives in the inner bark, in the cambium layer, and to a certain extent in the younger wood. Even at an early stage of the canker there may be a well defined line of separation between the healthy and diseased bark (Fig. 3). If the canker has not girdled the limb, the disease will not necessarily kill the branch attacked, but its growth is usually permanently arrested.

After the bark has fallen away from the original canker the fungus may persist and form a perennial canker, but usually the old canker

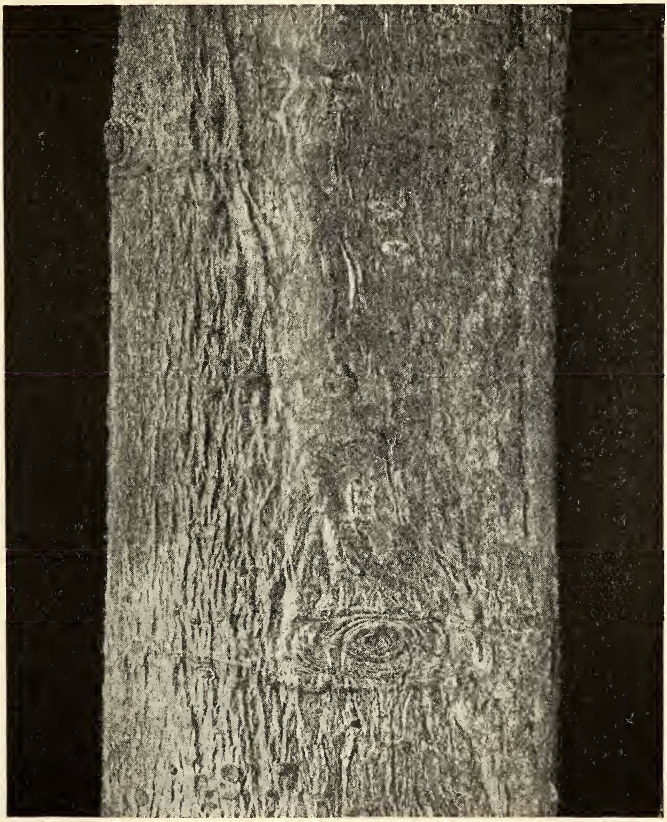


Fig. 3.— European Canker on apple branch, showing boundary of healthy and diseased areas.

merely becomes deeper and more gnarled by the growth of successive layers of wood and the attempt of the tree to heal the wound.

The crotch appears to be the favorite seat of first infection (Fig. 4), while later cankers appear farther up the branches. These spread rapidly over the tree and to new trees in the immediate vicinity. A tree with a crotch canker may have scarcely a healthy branch of any considerable size, and a single diseased tree may infect a dozen or more adjoining trees in a single season. It appears that from three to five years only are required for the total destruction of a young orchard.

Fungus.—The fungus which causes the European canker, like many other parasitic fungi, has two stages in its development, in each of which fruiting bodies and spores are produced which are very unlike each other. The first type of spore-bearing bodies to appear are the pink pustules mentioned above. These consist of a dense mat or cushion of fungous tissue upon which the almost colorless conidial spores are borne. Later in the season on the same cushion-like body there appears a small red flask shaped body known as the perithecium.

Fig. 4.– Large crotch canker of European Canker. Slightly reduced.

This is about one-twelfth inch in length, bright, almost scarlet red, with a distinct beak. Inside the perithecium are borne large numbers of spores in sacks, called asci.

So far we have found the conidial form of the fungus rather abundant, but the last named type has not been found so commonly. The conidial fruiting bodies of the European canker fungus are quite unlike those of any fungus related to it and agree well with those produced by the present fungus. While the conidia germinate readily and are easily cultivated, the spores produced by the ascus-bearing stage of the fungus do not lend themselves nearly so readily to study. Although this evidence all points to the presence in North Carolina of the European canker in a very virulent form, and while there is little room for doubting the correctness of the determination of this disease, further study may show our form to be a distinct but closely related fungus.

Resistant Varieties.—So far as the writer knows there does not appear to be any considerable difference in the resistance of varieties to this disease, all of those exposed becoming infected and sooner or later succumbing to the attack.

Fig. 5.— Thelephorose, showing fungous growth enveloping small branches. About natural size.

Treatment.—As the fungus which causes the European canker is supposed to be unable to enter the tree until the bark is first injured by some other agency, the freedom from this disease depends even more than in the case of the New York canker upon proper care of the orchard, in promptly removing all infective material, in avoiding wounding, and in protecting unavoidable wounds.

THELEPHOROSE.

History.—This disease first attracted attention in 1890, when the United States Department of Agriculture announced that apples in Texas and pears in Alabama were subject to its attacks. The first report of the disease to reach this Station was sent from Lincoln County in February, 1911, when some orchards were said to be rather seriously affected. It has since been reported from Mecklenburg, Polk and Yancey counties.

Cause.—This disease is so named as the fungus which causes the disease was formerly placed in the genus *Thelephora.* It is now known

Fig. 6.—Thelephorose. Cross section of fungous mat, showing spongy structure and large cavities below. Highly magnified.

as *Septobasidium pedicillatum* (Schw.), Pat. This fungus is a near relative of the toadstools and punk knobs which are common about stumps and logs and on dead or living timber.

Symptoms.—It occurs on the twigs or trunks of the tree, usually at a dormant bud or at the base of a fruit spur or twig. The spots are from one-half inch to four or five inches long and vary in width according to the size of the branch, sometimes completely surrounding it

(Fig. 5). The fungus is grayish brown or smoky colored, with lighter margins. The spots in time become sunken and the bark and wood beneath is seen to be dead. The fungus growth is easily removed and is of a very spongy texture to the touch. Upon examination with the microscope the reason for this becomes very apparent. While the outer portion of the fungus is continuous and rather closely and compactly formed, a little way beneath the surface large cavities appear. These enlarge toward the affected branch so that a cross section of the fungus has the appearance of a flat roof supported by pillars (Fig. 6). This is the characteristic which gives the fungus its specific name, *pedicellatum.*

Distribution.—This fungus occurs throughout eastern North America, as well as in Cuba, in Ceylon, and in New Zealand, growing upon various deciduous trees such as apple, pear, oak, etc., and on the palmetto. With such a wide range of hosts the fungus does not necessarily depend upon the orchards for its distribution and so may appear in destructive abundance in any orchard which is not well cared for. It has been recorded on the apple from West Virginia and Georgia, in addition to the localities mentioned above.

Treatment.—Cut out all badly diseased twigs, or in case of occurrence on the trunk or larger limbs remove all dead wood, washing the wound thoroughly in a saturated solution of copperas and cover with grafting wax or some similar substance. The quantity of copperas used in making the solution should be sufficient to allow some undissolved crystals to remain in the vessel. With proper care this disease should not prove serious. Winter spraying alone of dormant trees with strong fungicides will doubtless prevent it from gaining a foothold in orchards.

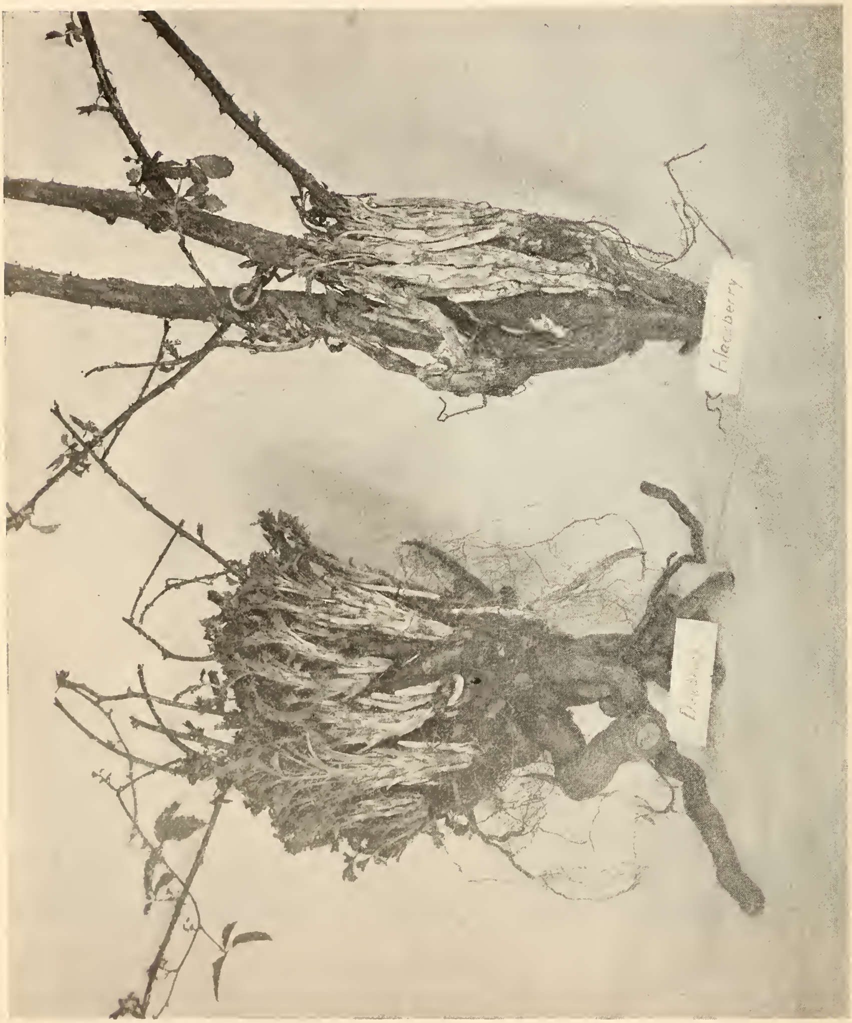


Fig. 7.– Crown of dewberry and blackberry affected with Orange Rust (Gymnoconia).

RUSTS OF BLACKBERRIES, DEWBERRIES, AND RASPBERRIES.

By Guy West Wilson.

These three fruits all belong to the genus *Rubus* of the rose family (*Rosaceæ*); and as might be expected from their close relationship they harbor, to a great extent, the same fungous pests. Of these pests the rusts are not the least common or destructive. Of these we have three forms in North Carolina, two of which certainly and the third in all probability are closely related to the rusts (*Phragmidium* spp.) which occur on various other members of the rose family. These three rusts vary in importance as well as in appearance.

Orange Rust (*Gymnoconia interstitialis* [Schlecht] Lagerh).

This is the most common and most widely spread of the bramble rusts. First discovered in northeastern Asia almost a century ago, it is now known not only in Europe and Asia, but almost throughout the United States. It infests a large number of species of blackberries, dewberries and raspberries, both wild and cultivated, and often causes severe losses. In fact several cases have come under the writer's notice where berry growing had to be abandoned for a time due to its ravages. The mycelium, or the threads of the fungus, live from year to year in the plant and spread to all its parts so that, once infected, the disease persists until the host plant is killed.

In the host plant the fungus acts as a stimulus to growth frequently causing an excessive number of young canes to be produced (Fig. 7), which appear at first to be more vigorous than the normal healthy canes, while at the same time development is retarded beyond a certain point. The leaves are dwarfed, and rolled and lacking in their normal green color, while the canes do not develop and bear fruit as they should.

Even in the early spring before the buds are fully unfolded, the fungus is apparent to a close observer. The leaves, especially on the upper surfaces, are covered with small, bright yellowish, columnar, waxy, glandlike bodies which enlarge as the leaves expand. These are the pycnidia or spermogonia which are present in all rusts but are not usually so conspicuous as in the present instance.

A little later the familiar bright orange colored spots appear in which are borne millions of spores. These spots are irregular in form and often run into each other (Fig. 8). They frequently cover the greater part of the surface of the leaf and produce spores so abundantly that the shoes and clothing of a person walking among infected plants becomes covered with them. These spores spread the fungus from one plant to another.

Later in the season inconspicuous spore masses of another type are produced, in which the winter spores are borne. These spores, as well as the perennial mycelium, carry the fungus over to another season, and like the more abundant early spores cause additional plants to become infected.

On account of the perennial nature of the fungus it is impossible to combat it except by digging and burning the infected plants. Care should be taken to prevent the spread of the disease among wild plants in the vicinity of plantations of berries as this furnishes a constant source of infection for healthy plants.

Late Rust (*Kuehneola albida* [Kuhn] Magnus.)

As its name indicates this rust does not appear until late in the summer, usually after the fruit is matured. This rust is rather inconspicuous, producing small light yellow or whitish spots (sori) on the under

Fig. 8.— Blackberry leaf, showing orange colored spots of the fungus Gymnoconia.

side of the leaves. The light color of these sori has given rise to the appellation of white rust which is, however, scarcely a correct name as the fungus is usually a light yellow in color.

While widely distributed over North America and Europe this rust has not given much trouble, yet under favorable conditions a serious outbreak of the disease might occur. This rust is unknown on the raspberry and seems to be confined to the blackberry.

Cane Rust (*Uredo muellerii, Schröt*).

This rust, also called the yellow late rust, occurs on wild and cultivated blackberries in eastern North America from New England southward. Although known in Europe for many years and first reported

Fig. 9.— Blackberry canes, showing the Cane Rust (Uredo muellerii).

in this county in 1900[1] from New York it has not been looked upon as a serious pest, the statement of its American discoverers being generally accepted. They say "there is no cause for alarm. * * * It appears too late in the season to do much damage." Observations in

[1]Stewart, Rolfs and Hall, N. Y. State Agr. Expt. Station, Bulletin 191, p. 306.

North Carolina extending over a number of years indicate that such a complacent view may be incorrect, at least in the more southern range of the species. Although no extensive examination of diseased plants has been made the fungus appears to be perennial. If this is true it may assume a very important role in the growth of certain varieties of blackberries in the South.

Just before, or about blooming time the rust makes its first appearance with us, first as a cane rust and later in the season as a leaf rust. This rust produces conspicuous spots on the canes from the ground up. These spots are often a third of an inch long and about half as wide, although they average a little smaller (Fig. 9). These sori are accompanied by tiny waxy pycnidia, which are very inconspicuous. Spores are produced in large numbers but not nearly so abundantly as in the case of the orange rust (Fig. 10).

Fig. 10.—Sorus of Uredo muellerii on blackberry. Enlarged 20 times.

Throughout the summer small rounded sori appear on the leaves which are also accompanied by pycnidia, and which resemble in certain ways the sori of the late rust (*Kuehneola*), but differ from them in several respects. The sori are bright yellow instead of almost colorless and usually appear on the upper side of the leaf more abundantly than on the lower, while in the late rust the reverse is true. The rust is not abundant enough on the leaves to cause any serious damage.

Only the early stages in the life history of this rust are known. From the frequent association on the same plant of this rust and *Kuehneola* and the absence of known winter spores in this species it has been assumed that *Uredo muellerii* represents the first part of the life cycle and *Kuehneola albida* the later stages of the same rust. This has not been proven by experiment, the one never having been grown from the other, and until this is done this can be only an assumption.

This rust occurs from year to year on the same host plant, and its habit of producing sori throughout the entire length of the cane indicates that it is a perennial fungus. Its chief damage to the host would lie in a weakening of the canes with consequent lessened productivity. This can be largely overcome by proper pruning in the spring. While this rust is not nearly so serious as the orange rust it may prove to be a more serious disease than at first supposed.

INFECTION OF APPLE LEAVES BY CEDAR RUST.

By H. R. Fulton.

The Orange Rust or Cedar Rust of apple leaves and fruit is caused by one or the other of several species of *Gymnosporangium,* but mainly by *Gymnosporangium macropus,* and it is to this species that the statements in this account relate. This fungus causes the swellings known as "cedar-apples" on the twigs of red cedars, and it is in these that the fungus lives over winter. In early spring the fungus forms large yellowish-brown spores (teleutospores) in pustules in the cedar-apples. Warm rains from March into May may cause these spores to exude in gelatinous horns, and if sufficiently prolonged will give them a chance to germinate in these horns. On germination they at once form a short threadlike growth, known as the promycelium, which in turn quickly produces a certain number of smaller, more delicate spores that are capable of infecting the apple immediately if they get the chance. From the first swelling of the gelatinous horns to the formation of the infection spores about 24 hours of moisture are required. These infection spores retain their vitality for only a short period, which varies with their surroundings. Not all the teleutospores germinate during any one wet period, but do so at several times during the spring whenever moisture conditions favor.

Apples can be infected only when viable infection spores reach them from the cedar-apples, and this depends intimately upon weather conditions during the spring months; furthermore, weather conditions must be favorable for the germination of the infection spores after reaching apple leaves or fruit. Along with the presence of infection spores and favorableness of weather conditions, susceptibility of the host is a third factor concerned in infection.

Cedar-apples on red cedars are very constant in occurrence each season. But apples in the eastern United States are severely attacked by this fungus at irregular intervals of years. Ordinary applications of fungicides have not given uniform success in controlling the disease. This study was undertaken to ascertain the importance of factors influencing infection with a view to explaining the irregularity in outbreaks and to finding a clue to a more successful spraying practice for it. Leaf infection only is here considered.

Varieties of apple differ much in their susceptibility to this disease, as may be readily observed in any mixed orchard that is attacked. In the spring of 1912, near Raleigh, N. C., observations show that Fallawater (Pound), Horse, Shockley, Red June, and Rome Beauty varieties are much affected on foliage; that Hoover, Magnum Bonum, Red Limbertwig, and York Imperial are moderately affected; that Buckingham, Winesap, Stayman Winesap, Salome, Paragon, Williams, and Maiden Blush are slightly affected; and that Arkansas, Delicious, Jefferis, Magnate, Lawver and King David are not at all affected.

In the experimental tests, inoculations were made by spraying infection spores with an atomizer on the leaves, usually just about sunset.

Cedar-apples were placed in moist dishes twenty-four to forty-eight hours before to insure good infection spores. Inoculations were made almost daily from March 26 to May 7, under all sorts of weather conditions. They were made on Fallawater, Magnum Bonum, Salome, Winesap, Stayman Winesap, Arkansas, Lawver, Paragon, and one unknown variety of apple, and on two unknown varieties of crab-apple.

Weather conditions that prevailed during the test are indicated in the following table compiled from reports of the Raleigh Station of the United States Weather Bureau. Days with no rainfall are omitted.

Date.	Mean Temp.	Rainfall in Inches.	Percentage Sunshine.	Date.	Mean Temp.	Rainfall in Inches.	Percentage Sunshine.
March 22	56	.17	0	April 20	54	.17	11
23	38	.91	0	21	56	.09	0
24	48	.25	0	22	64	1.93	18
25	47	.08	78	23	60	.01	100
28	58	trace	9	26	62	trace	42
29	66	1.45	59	27	65	.02	27
April 1	64	.16	25	29	69	.75	39
2	68	trace	52	30	70	.01	74
7	58	.29	4	May 5	67	.19	36
10	64	trace	50	6	72	1.57	27
13	65	.02	10	7	74	.36	41
16	71	.06	36				
17	71	.23	23				
18	71	trace	67				

Infection resulted from certain of the trials made on Fallawater, Magnum Bonum, Salome, Winesap, Stayman Winesap, and Paragon, but not on the other varieties tested. For these there was considerable difference between the most susceptible variety, Fallawater, and the least susceptible, Paragon, both in the rate of development of the spots, and in the size ultimately attained, while there was not so great difference in the number of spots per leaf. It seemed that infection started on all susceptible varieties, but that growth of the fungus was inhibited in the most resistant ones before the spots had reached any considerable size.

The two periods during which artificial infections occurred were uniform for the varieties and centered about April 1 and April 21. Since Fallawater showed the effects most conspicuously, and since the other affected varieties did not present any exceptional conditions, the data for it alone will be given. The first infection was noted April 15 on leaves inoculated March 28, and the spots were then 1-12 inch across and showed spermogonia. At the same time infections of March 30 and more abundantly of April 1 appeared as smaller yellowish dots. Twenty-four twigs developed this early infection. Attempts to inoculate had been made every day from March 26 to April 2, with the exception of March 31. While there was no rain March 30, the day was humid and still. That infections did not occur on the other four days when similar infective material was placed on leaves of similar development, suggests the sensitiveness of the infection spores to external conditions.

On March 26 the Fallawater flower cluster buds were opening, exposing the leaves about one-fourth inch beyond the bud scales. The flower buds proper were still fairly well covered by the unexpanded leaves. The leaf buds were swollen, occasionally showing slight green. By April 3 the flower buds proper were exposed but the petals were not showing between the sepals. The leaves were one-fourth to three-fourths inch long.

This early infection was practically confined to fruit spurs which produced a total of six or seven leaves, including the lowermost two or three small, bract-like leaves. Only two out of the twenty-four twigs showed infection beyond the third leaf from the bottom. The majority of the twigs had no infection on the first leaf. Infection was, therefore, typically on the second and third leaves rather than on others.

Why was it that during these inoculations the one lowermost (oldest) leaf escaped infection in the majority of cases, and several uppermost (youngest) leaves escaped constantly, although the development of the buds was such as to favor the lodging of infection spores on all? The reasonable answer seems to be that each leaf is most susceptible during a brief period only in its development, and that at younger and older stages it is less susceptible or entirely immune. The fact that some of the youngest leaves on these same twigs became infected three weeks later, and that none of the older leaves developed any of the later infection, further substantiates the point, as do other facts that will be brought out later.

In their later development the spots on the bract-like leaves seemed to form a thicker cushion than spots of equivalent age on normal foliage leaves.

The second period of artificial infection centered about April 21 and was first noticed as small spots on April 30. Natural infection occurred about the same time; the experimental twigs were not protected from this, and the exact determination of days was slightly complicated thereby. There was some infection on April 16 and 20, but it was small in amount, not nearly so much as on April 21, and will not be considered. Inoculation dates were April 15, 16, 17, 20, 21 and 24.

Fifteen Fallawater twigs became infected at this time artificially. None of these showed infection lower than the fourth leaf, in seven it began on the fourth leaf, and in the other eight on the fifth or sixth leaf. Typical infection involved all the leaves above these on the stem, although in five cases one or more topmost leaves escaped infection. However, three of such twigs were terminal shoots that were elongating and forming new leaves indefinitely. Maximum infection was typical about midway of the three or four leaves showing infection, the first and last affected leaves having distinctly fewer spots than those between.

On April 16 the petals had all fallen and the new shoots were a little more than one inch long and showed seven or eight leaves, the full number except for those continuing indefinite growth. At this time the sixth leaf was about half full size, and this is the leaf that on the average seemed most susceptible during the next few days.

Natural infection was first noted on Fallawater on April 30, when minute infection spots appeared generally on certain leaves on most of its twigs. In a few days similar infection could be detected on other varieties. From comparisons with the series of artificial inoculations it is certain that this infection dates from the showery period of April 20-22. No other natural infection corresponding to other rainy periods was detected.

The condition of the teleutospores in the cedar-apple horns is interesting in this connection. On March 26 the horns barely protruded, and only about 1 per cent of the teleutospores had germinated. The hard rain of March 29, confined to the night with clearing in the forenoon, did not greatly alter their condition. By April 12, 10 per cent of the teleutospores had germinated; by April 19, 35 per cent; by April 25, 75 per cent; by May 2, 90 per cent, and by May 7, practically all. The period of greatest germination, April 19 to 25, includes that of the natural infection in question.

Examination of a large number of twigs of Fallawater naturally infected during this period shows that the lowermost affected leaf was usually the fifth from the bottom, and never lower than the third nor higher than the seventh; that the uppermost affected leaf was usually the eighth; that the sixth and seventh showed most abundant infection, with gradation in degree up and down, three or four leaves in all out of eight or nine on the typical twig having any infection. Frequently the spots on the lowermost infected leaf were quite small, as on more resistant varieties.

These data agree with those from twigs artificially infected at the same period. All go to show that the lowermost and oldest leaves on the twigs were not infected, although equally exposed with others to infection spores and to favoring moisture. These must have passed with increasing age of the individual leaf from a condition of susceptibility into one of non-susceptibility, and by April 22, 1912, almost half the leaves on this Fallawater tree had reached such a condition of immunity. Passing further outward along the twig are the zones of partial susceptibility, of maximum susceptibility, and again of partial susceptibility or of immunity apparently due to young condition. It may be that the escape of very young leaves is due in part to lessened chance for spores to lodge on them when unexpanded; but this does not seem from the facts to be the whole explanation.

It is seen that for the season of 1912 teleutospores were capable of germination for about six weeks; that they formed infection spores abundantly only when there was continuous wet weather for about two days; that infection of apple leaves was produced by these spores only when the wet weather was more prolonged, giving a chance for germination after being distributed; that only a certain proportion of apple leaves on any twig were infected at any one time; that the susceptibility of the leaves was determined by their age; and that at least some leaves were susceptible in some degree from the bursting of the buds until about two weeks after the falling of the petals. All of these facts accord essentially with those obtained by the writer during the spring of 1911 in the vicinity of State College, Pennsylvania.

To give adequate and sure protection it would seem that spraying for this disease should be begun just after the leaves emerge from the buds, and should be repeated as often as necessary to keep the expanding leaf surfaces protected. The failure of ordinary spraying to protect has probably been due to beginning too late or to too infrequent applications. Infection really occurs ten days before the spots become apparent. A tentative schedule, recommended for trial, would include applications (1) just after the leaves are out of the bud, (2) just before the blossoms open, (3) just after the petals fall, and (4) ten days later. It will be noted that the last three of these applications coincide with those for full scab treatment. Only decidedly susceptible varieties need be thus protected. The danger period is only during wet weather; but to protect the spraying must be before, not after such a period. If weather conditions could be foretold with exactness one or two sprayings could be made to do the work. When all is said, the inherent difficulties in the spraying method of control strongly emphasize the importance of removing from the vicinity of the orchard the red cedar trees that are the source of contagion. Usually bad infection comes from cedars very close at hand that it will be possible to get rid of. The farther away the cedar tree is, the less chance is there of spores from it reaching any particular apple tree. With coöperative interest in cedar tree removal, it is not probable that spraying for this disease would be often necessary.

V—STUDIES IN SOIL BACTERIOLOGY[1]

NITRIFYING AND AMMONIFYING POWERS OF NORTH CAROLINA SOILS.

By

F. L. Stevens and W. A. Withers,

assisted by

P. L. Gainey and T. B. Stansel.

The strikingly low nitrifying power noted in preliminary bacteriological studies of certain soils[2] emphasized the importance of obtaining more extensive and accurate knowledge concerning this function. To that end plans were drawn for an examination of samples of the leading soil types, to be taken in such localities as to give as adequate a representation of the soils of this State as was practicable. The samples were taken from areas already covered by the United States Soil Survey and were all examined by George M. MacNider, of the North Carolina Department of Agriculture, formerly of the United States Soil Survey, who made definite determination of the type in hand in each instance. We very gratefully acknowledge our indebtedness to Mr. MacNider for this kindness.

In each instance, with three exceptions, the soil samples were taken in pairs for purposes of comparison; one sample of the pair from a very rich field of the type in question, the other from a very poor field of identically the same type of soil, preferably located in an adjacent field; in several instances from a poor spot in the same field from which the rich sample came. The samples were collected in tin pails with tightly fitting tops, were sent to the laboratory by express and the determinations were made shortly after their receipt, with the exception of determinations of Nitrifying Efficiency (N. E.), which were in some instances delayed.

The following directions were given to each collector in order to eliminate as far as possible any error from contamination:

"Pull all vegetation from the place to be sampled.

"At one stroke with a shovel, remove one inch of the surface from an area one to two square feet.

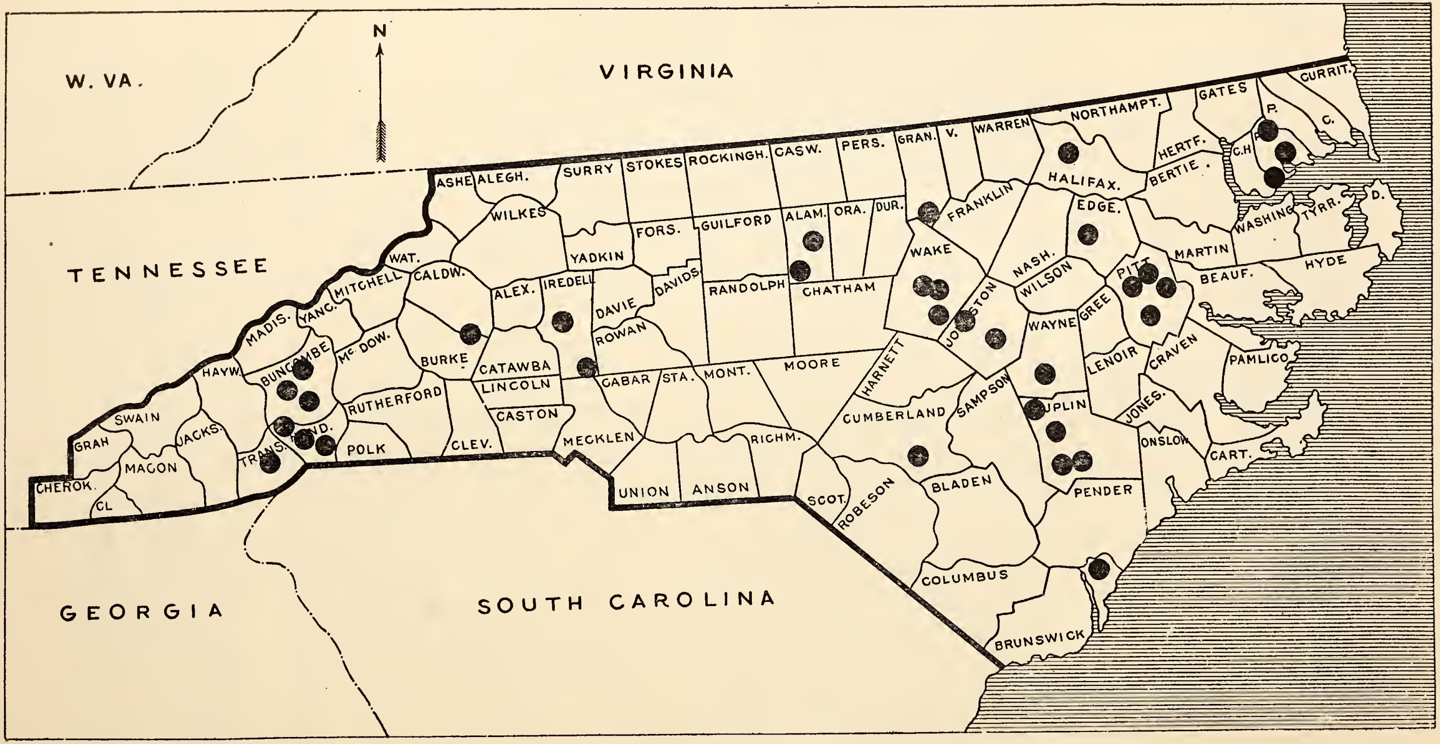
"Remove about ¼ inch more with the sterile trowel provided in the pail.

"Fill the pail with soil so exposed, free from stones, sticks, roots, etc., using the sterile trowel.

"Use every precaution to avoid allowing dust or organisms from any source other than the soil to fall into the pail."

[1]Articles I, II, III, and IV appeared in Centralblatt für Bakteriologie, Ab. II, Bd. 23, 25, and 27.
[2]Science N. S. 29, 743. 506, Mch. 1909.

North Carolina.



MAP SHOWING THE LOCATION OF THE SOILS SAMPLED.

Notes in the following blank form also elicited desired information:

Yielding power in bushels of shelled corn per acre............................
Yielding power in pounds of seed cotton per acre.............................
Yielding power, regarding any other crop, per acre...........................
Crops grown 1909............Fertilizer or manure used in 1909............
Crops grown 1908............Fertilizer or manure used in 1908............
Crops grown 1907............Fertilizer or manure used in 1907............

In the study of nitrifying power the following determinations were made:

N. E.: Nitrifying Efficiency.

N. I. P.: Nitrification Inoculating Power.

Also for purposes of comparison of methods the N. I. P. was determined in solution.

Determinations of ammonification were made as follows:

A. E.: Ammonification Efficiency.

A. I. P.: Ammonification Inoculating Power.

A. I. P. in solution.

These terms and methods of making the determinations were discussed in full in a recent article.[1]

If it is desired to convert our coefficients for nitrification to parts of nitrate nitrogen per million parts of soil this may be done by multiplying our coefficient by six.

The soil survey was begun March 4, 1909, and concluded January, 1911. In all seventy-nine soils were examined, 37 of these being poor and unproductive, while the productivity of three which had never been cultivated was unknown.

The soils came from twenty counties in North Carolina as follows: Alamance 6, Buncombe 6, Caldwell 2, Chowan 4, Craven 2, Cumberland 2, Duplin 8, Edgecombe 2, Granville 2, Henderson 6, Hertford 2, Iredell 6, Johnston 4, New Hanover 4, Pasquotank 1, Perquimans 4, Pitt 8, Transylvania 2, Wake 6, Wayne 2. The location of the soils sampled is shown on the accompanying map.

The soil types represented were as follows: (1) Cecil clay 4, (2) Cecil sandy loam 8, (3) Conowingo sandy loam 2, (4) Iredell clay loam 4, (5) Meadow 2, (6) Norfolk coarse sandy loam 2, (7) Norfolk fine sand 3, (8) Norfolk fine sandy loam 4, (9) Norfolk sand 6, (10) Norfolk sandy loam 11, (11) Norfolk very fine sandy loam 2, (12) Orangeburg fine sandy loam 2, (13) Pocosin 1, (14), Porter's clay 2, (15) Porter's loam 2, (16) Porter's sandy loam 6, (17) Portsmouth fine sandy loam 5, (18) Portsmouth loam 1, (19) Portsmouth sand 2, (20) Portsmouth sandy loam 2, (21) Portsmouth very fine sandy loam 2, (22) Savannah 1, (23) swamps 1, (24) Toxaway loam 2, (25) Toxaway sandy loam 2.

In all 679 factors were determined as follows: N. I. P. in soil, 79; N. I. P. in solution, 79—1909; N. I. P. in solution, 57—1910; A. E., 79; A. I. P. in soil, 73: A. I. P. in solution, 71; N. C., 47.

This involved a total of approximately 1796 flasks of soil, each incubated separately, and in all required the following chemical analyses:

[1]Stevens and Withers, III Soil Bacteriology, Centralblatt für Bakteriologie, B. 25, S. 64.

N E., 548; N. I. P. in soil, 272; N. I. P. in solution, 272; A. E., 316; A. I. P. in soil, 146; A. I. P. in solution, 142; N. C., 100, or a total of 1,584 chemical determinations, viz.: Nitrates, 592; nitrites, 592; ammonia, 604; nitrates and nitrites, 1,796.

The results in their entirety are presented in the table accompanying this article. The original plan provided for the determination of all the factors in each collection of 1909, but in testing the method[1] for nitrites and nitrates it was found to be less delicate than desired. It was thought best, therefore, to set aside all the zeros for nitrites and nitrates for the 1909 samples. During 1910 samples were again taken from the same localities and determinations of the N. E., N. I. P. in soil and N. I. P. in solution made on these samples.

In 1910 we used a modification of the diphenylamine method by Withers and Ray[2] which the authors found to show as little as one part of nitrate and nitrite nitrogen in thirty-five millions of water, which is equivalent to about 0.3 pounds in an acre of soil. When nitrates or nitrites were indicated by the method the amounts were determined quantitatively—nitrites by the Griess[3] method and nitrates by the phenol disulphonic acid[4] method or the Tiemann-Schulze[5] method.

Nitrification.

COMPARISON OF METHODS.

Table I.—Showing comparison by different methods, calculated to per cent.

	N. E. with N. I. P.			N. E. with N. I. P. in Solu.			N. I. P. in Soil with N. I. P. in Solu.		
	Both Methods Give a Test.	Only One Method Gives a Test.	Total.	Both Methods Give a Test.	Only One Method Gives a Test.	Total.	Both Methods Give a Test.	Only One Method Gives a Test.	Total.
N. E. Greater	5.3	0.0	5.3	33.3	17.5	50.8	--------	--------	--------
N. I. P. Greater	49.1	43.8	92.9	--------	--------	--------	64.3	30.3	94.6
N. I. P. in Solu. Greater	--------	--------	--------	0.0	35.1	35.1	3.6	1.8	5.4
Total	54.4	43.8	98.2	33.3	52.6	85.9	67.9	32.1	100.0
Both methods give same result.	--------	--------	0.0	1.8	--------	1.8	--------	--------	--------
Both methods give zero	--------	--------	1.8	--------	--------	12.3	--------	--------	0
	--------	--------	100.0	--------	--------	100.0	--------	--------	100.0

[1]Treadwell, Vol. I (1904), p. 340.
[2]Jour. Am. Chem. Soc., 33 (1911), 708.
[3]Bul. 31 Bureau of Soils, U. S. Dept. Agr., p. 41.
[4]Ibid., p. 39.
[5]Fresenius, Vol. I (1909), p. 582; Treadwell, Vol. II (1909), p. 360.

N. I. P. in soil with N. I. P. in solution.—By examining the above table No. 1 we see that of the soils tested 67.9 per cent showed N. I. P. in both soil and solution, 30.3 per cent showed N. I. P. only in soil and 1.8 per cent showed N. I. P. only in solution. The N. I. P. in soil was greater than in solution in 94.6 per cent of the samples and less in 5.4 per cent of the samples. It is evident from these results that the changes which take place in solution can not be accepted as an index to the changes which take place in the soil.

N. E. with N. I. P. in solution.—Of the soils tested 35.1 per cent showed both N. E. and N. I. P. in solution, 17.5 per cent showed only N. E., 35.1 per cent showed only N. I. P. in solution, and 12.3 per cent did not show nitrification by either method. The N. E. was greater than N. I. P. in solution in 50.8 per cent of the soils, was less in 35.1 per cent of the soils and was equal in 1.8 per cent of the soils in which there was nitrification by both methods, and in 12.3 per cent of the soils in which there was no nitrification by either method. It is evident from these results that the changes which take place in solution cannot be accepted as an index to the changes which take place in the soil.

N. E. with N. I. P.—Of the soils tested 54.4 per cent showed both N. E. and N. I. P., 43.8 per cent showed only N. I. P., and 1.8 per cent showed no nitrification by either method. N. E. is greater than N. I. P. in 5.3 per cent of the soils, is less in 92.9 per cent of the soils and is equal in 1.8 per cent of the soils in which there is no nitrification by either method.

General.—Every soil showed some nitrification by one or other of the methods, thus proving that in every soil there were living nitrifying organisms. Every method in one or more instances failed to show nitrification, thus proving that no method which we used afforded satisfactory conditions for the activities of the complexes in all the soils, one method being better suited to one complex, another to another complex, and that the findings by one method could not be taken as indicating what would be the findings by another method.

N. I. P. in solution was unsatisfactory in that the coefficients had a very narrow range and were all small. N. I. P. was unsatisfactory in that its coefficients were all very large, but satisfactory to the extent that all soils but one gave positive results. N. E. was unsatisfactory in that so many of the coefficients were zero or less, but there is in its favor that fact that the soil is used in its natural state without sterilization, and that as a rule the coefficients are not excessively large.

The fact that 42.6 per cent of the soils failed to show nitrification by the N. E. method when the conditions of temperature, moisture, etc., were arranged to be much more favorable to the activity of the nitrifying organisms, than under ordinary field conditions, suggests that the plant is not so dependent upon nitrates for its nitrogen as is generally supposed.

Variation in Nitrification at different periods.—Some of the soils which we used during 1909 were again sampled during 1910, the samples being taken from the same fields and by the same sampler. Some of these results are given in table 2.

TABLE II—Showing a variation from year to year.

	N. E.			N. I. P.	
	1909.	1910.		1909.	1910.
No. 5	5.5	6.5	No. 5	4.7	74.1
No. 35	29.7	—10.6	No. 35	5.2	87.7
No. 29	16.1	0.0	No. 42	6.0	50.6
No. 31	39.5	36.1	No. 57	30.5	73.6
No. 47	13.5	0.0	No. 61	35.9	74.6
No. 49	50.6	—0.7	No. 65	60.2	85.3
No. 81	22.4	14.8	No. 66	4.5	46.0
			No. 67	65.8	4.3
Average	25.6	6.6	No. 69	30.7	0.0
			No. 75	35.1	6.2
			No. 77	11.6	27.5
			No. 78	3.3	3.9
			No. 79	62.6	29.2
			No. 80	43.1	82.6
			Average	28.5	46.1

These results given in table 2 show a great difference between the results for 1909 and 1910 in both N. E. and N. I. P. Strange to say the average of the N. E. decreased from 1909 to 1910 and of N. I. P. increased. Except in two cases the N. E. and N. I. P. were made on samples from different fields. In some cases soils which gave good nitrification one year showed none the following year.

CORRELATION BETWEEN FERTILITY AND NITRIFICATION.

The following table shows the relation between fertility and nitrification in soils as determined by the different methods.

Percentages of the pairs of good and poor soils nitrifying by different methods.

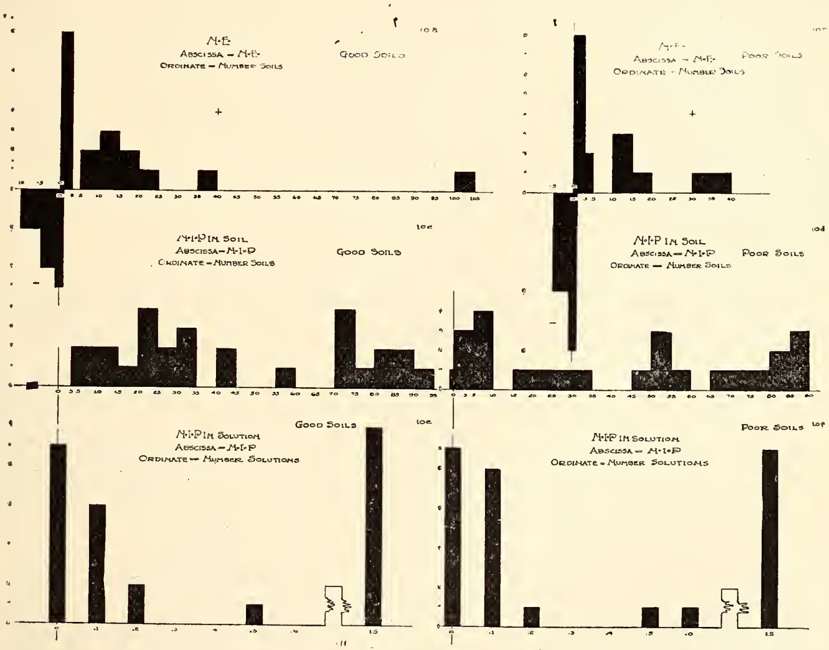
TABLE III.—Comparing nitrification by different methods.

	N. E.			N. I. P.			N. I. P. in Solu.			Average.		
	Both Nitrify.	Only One Nitrifies.	Total.	Both Nitrify.	One Nitrifies.	Total.	Both Nitrify.	One Nitrifies.	Total.	Both Nitrify.	One Nitrifies.	Total.
Greater nitrification by:												
Good soils	29.7	14.8	44.5	65.4	3.8	69.2	3.8	3.9	7.7	33.0	7.5	40.5
Poor soils	14.8	11.1	25.9	30.8	.0	30.8	3.8	.0	3.8	16.4	3.7	20.1
Total	44.5	25.9	70.4	96.2	3.8	100.0	7.6	3.9	11.5	49.4	11.2	60.6
Good and poor soils equal in nitrification.	------	------	.0	------	------	.0	57.7	------	57.7	19.2	------	19.2
Neither nitrifies	------	------	29.6	------	------	.0	------	------	30.8	------	------	20.2
	------	------	100.0	------	------	100.0	------	------	100.0	68.6	------	100.0

TABLE IV.—Showing summary of results by different methods.

	N. E.	N. I. P.	N. I. P. in Solu.
Maximum coefficient	105.1	89.9	1.5
Average for good soils	8.7	44.7	0.6
Average for poor soils	5.0	34.8	0.6
Average for all soils tested	6.8	39.8	0.6

The results by different methods for good soils and for poor soils are shown graphically by the following cuts:



N. I. P. in Solution and Fertility.—N. I. P. in solution shows the least correlation between fertility and nitrification, the good and the poor soil showing the same nitrification in 88.5 per cent of the pairs. The good soil gave greater nitrification than the poor in 7.7 per cent of the pairs and less in the case of 3.8 per cent of the pairs. The average for the good was the same as for the poor and the maximum was only 1.5 per cent.

N. I. P. and Fertility.—In the case of N. I. P., every soil showed nitrification except one poor soil. The good soil gave better nitrification than the poor in 69.2 per cent of the pairs, and less in 30.8 per cent. of the pairs, an excess in favor of the good in 38.4 per cent.

In Table V the difference of N. I. P. in favor of the good soils is strikingly shown:

TABLE V.

Type.	County.	N. I. P.	
		Good soil.	Poor soil
Cecil clay	Iredell	41.1	4.5
do	Alamance	78.7	5.4
Cecil sandy loam	Granville	85.3	46.0
do	Iredell	27.5	3.9
Conowingo sandy loam	Caldwell	80.7	30.0
Norfolk coarse sandy loam	Wake	10.7	5.8
Norfolk fine sand	Duplin	74.1	23.8
Norfolk sand	Wayne	23.2	0.9
Norfolk sand	Cumberland	4.3	0.0
Norfolk sandy loam	Johnston	6.2	0.9
Porter's sandy loam	Buncombe	30.4	5.0
do	Henderson	40.3	6.4
Portsmouth fine sandy loam	Perquimans	74.6	1.3
Portsmouth sand	Duplin	87.7	5.5
Toxaway sandy loam	Henderson	32.7	17.5
Average		46.5	10.5

On the other hand in Table VI the difference of N. I. P. in favor of the poor soils is more strikingly shown:

TABLE VI.

Type.	County.	N. I. P.	
		Good soil.	Poor soil.
Cecil sandy loam	Alamance	29.2	82.6
Meadow	Wake	18.7	87.5
Norfolk fine sandy loam	Pitt	22.9	76.0
Norfolk very fine sandy loam	do	11.3	28.7
Orangeburg fine sandy loam	Duplin	3.5	86.7
Portsmouth fine sandy loam	Chowan	23.2	80.5
Toxaway loam	Transylvania	20.4	52.8
Average		18.5	70.7

The average N. I. P. for all the good soils was 44.7 per cent, of the poor soils 34.8 per cent and of all soils 39.8 per cent. The excess of the average of the good over the poor soils was 9.9 per cent or 24.9 per cent of the average. This method is good in that it usually shows nitrification. It is objectionable in that the average (39.8) represents the production of nitrate nitrogen equivalent to the amount of 955.2 pounds to the acre for a month or 1965.6 for three months, which is greatly in excess of the possible amount in the field under ordinary agricultural conditions.

N. E. and Fertility.—The N. E. would probably be regarded popularly as the factor of most significance since it is at least an approximate measure of the power of the soil to furnish nitrate nitrogen to the plants that may grow upon it. How important this factor really is is not yet accurately known. It may be very important. In some instances it may be of no significance.

It will be noted that seven rich soils showed N. E. ranging from 12.6 to 105.1 with an average of 32.3. These soils had an average corn yield of 36.4 bushels an acre. On the other hand eleven rich soils showed N. E. zero or less than zero and had an average corn yield of 35.5 bushels an acre. *In other words, the rich soils with an N. E. of 32.3 had about the same corn producing power as rich soils which showed no N. E.*

In Table VII the good soils exceeded the poor soils in nitrification.

TABLE VII.

Type.	County.	N. E.	
		Good soil.	Poor soil.
Cecil clay	Iredell	2.0	1.0
do	Alamance	36.1	11.7
Cecil sandy loam	Granville	2.2	0.1
do	Alamance	2.2	1.3
Conowingo sandy loam	Caldwell	105.1	0.1
Norfolk fine sand	Duplin	6.5	0.5
Norfolk sandy loam	Johnston	12.6	0.0
Porter's loam	Buncombe	21.1	—0.8
Porter's sandy loam	do	14.8	4.9
Portsmouth fine sandy loam	Perquimans	9.9	0.0
Toxaway sandy loam	Henderson	17.1	10.2
Average		20.9	2.7

On the other hand, in table 8 the good soils showed less nitrification than the poor soil:

TABLE VIII.

Type.	County.	N. E.	
		Good soil.	Poor soil.
Iredell clay loam	Iredell	19.2	34.2
Meadow	Wake	2.2	13.3
Norfolk sand	Hertford	1.8	17.3
Orangeburg fine sandy loam	Duplin	0.0	3.5
Portsmouth very fine sandy loam	Chowan	—0.7	38.8
Average		4.5	21.4

Considering all the soils examined *the good soils gave better N. E. than the poor soils in* 44.5 *per cent of the pairs and less in* 25.9 *per cent of the pairs,* an excess in favor of the good soil of 18.5 per cent. *In* 29.6 *per cent of the pairs, neither the good nor the poor soil showed any nitrification.* Of the pairs in which only one showed nitrification, it was the good soil in 14.8 per cent of the pairs and the poor soil in 11.1 per cent of the pairs.

The average N. E. for all the soils was 6.8. For the good soils N. E. averaged 8.7 and for the poor soils 5.0, an excess of 3.7, or 55.1 per cent of the average N. E. in favor of the good soils.

That our zeros are not absolute zeros is to be expected. In the determination of nitrites and nitrates in this paper we have not considered coefficients less than 0.1. This would correspond to nitrates and nitrites equivalent to 2.4 pounds of nitrogen found in an acre in one month, or 7.2 pounds per acre (approximately 7.2 kilograms per hektare) in three months. Crops require much more nitrogen than this, wheat 20 bu. per acre removes 35 lbs.; corn 65 bu. per acre, 75 lbs.; potatoes, 150 bu. per acre, 40 lbs. Oats, 30 bu. per acre, 50 lbs. Barley, 40 bu. per acre, 40 lbs.[1]

It therefore appears that the soils which we record as of no N. E. are incapable of producing sufficient nitrate nitrogen to feed such crops, particularly as all the nitrate nitrogen in the soil can not in any case be available for the plant.

The soils recorded as having N. E. less than .4 (equals 28.8 lbs. of nitrogen per acre during three months) are also incapable of supplying enough nitrate nitrogen to the soil for the crop.

On the other hand some of the soils of good N. E. both here reported and previously reported have ample power to supply an abundance of nitrate nitrogen. For example soil No. 39 with N. E. 105.1 would produce during three months 7,567 lbs. of nitrate nitrogen per acre—an amount so large as to be entirely beyond conception in practice.

A question of serious practical importance, therefore, is whether the plants require nitrate nitrogen to supply their needs for nitrogen or whether some other forms of nitrogen will serve equally well.

The fact that so large a proportion as 42.6 per cent of the soils tested by us showed no N. E. is a condition not usually expected in arable soils.

Scrutiny of the comparison of N. E. with N. I. P. in soil and in solution shows that these factors do not run parallel, a fact that was postulated in our earlier article.[2]

The N. I. P. and the N. E. must be regarded as separate functions of the soil which must be separately measured.

In general the N. I. P. was higher in the good than in the poor soils. The average was 44.7 per cent for the good soils and 34.8 for the poor soils. None of those which showed N. E. failed to show N. I. P. in soil and 17.5 per cent of those which showed N. E. failed to show N. I. P. in solution. Forty-three and eight-tenths per cent of those with

[1]Snyder's Soils and Fertilizers, p. 129.
[2]Stevens and Withers, III Soil Bacteriology, Cent. f. Bak. II, Abt. Bd. 25, p. 64.

N. I. P. failed to show N. E. and 30.8 per cent of those which showed N. I. P. failed to show N. I. P. in solution. Thirty-five and one-tenth per cent of those with N. I. P. in solution failed to show N. E. and 1.8 per cent of those which showed N. I. P. in solution failed to show N. I. P. in soil. The variations shown between N. I. P. in soil and N. I. P. in solution and N. E. all go to show that a given complex of soil organisms will give different records in different modes of test; soil favors some complexes, solution favors others; one soil may favor one bacterial complex more than it favors another complex. The results strongly support the use of soils rather than solutions for soil study.

It is peculiar that the N. I. P. in soil should so often (92.9 per cent of the cases) exceed the N. E., though in only 35.1 per cent does the N. I. P. in solution exceed the N. E. This would indicate that the standard soil used is superior to most of the samples examined as a medium for the growth of the nitrifying complexes used and that soil is superior to solution in this respect.

That nearly all soils showed N. I. P. in soil indicates that even though the soils did not show N. E. the organisms necessary to nitrification were present and that the responsibility for low N. E. rests rather with the soil itself than with any deficiency in its bacterial flora.

AMMONIFICATION.

Regarding ammonification it is seen that considering all the samples the A. E. ranges from .03 to 25.46 with the most of the samples giving an A. E. of between 5 and 20. With the poor soils the A. E. was mainly from 5 to 20, and with the good soils it was the same. In other words there is no apparent correlation between fertility and A. E.

Tabulating the soils of low A. E. for comparison with those of high A. E. the following is obtained:

Of 11 soils of A. E. 5, 2, or 2.6 per cent of the whole were poor.
Of 11 soils of A. E. 5, 9, or 11.8 per cent of the whole were good.
Of 28 soils of A. E. 15, 13, or 17.0 per cent of the whole were poor.
Of 28 soils of A. E. 15, 11, or 14.4 per cent of the whole were good.
The detailed statement is shown in the following table.

TABLE IX.

A. E.	Number.			Percentage.		
	Good.	Poor.	Total.	Good.	Poor.	Total.
25 per cent	1	0	1	1.3	0.0	1.3
20–25 per cent	1	4	5	1.3	5.3	6.6
15–20 per cent	9	9	18	11.8	11.9	23.7
10–15 per cent	9	6	15	11.9	7.8	19.7
5–10 per cent	10	16	26	13.2	21.0	34.2
0– 5 per cent	9	2	11	11.8	2.7	14.5
Total	39	37	76	51.3	48.7	100.0

A. E.	Number.			Percentage.		
	Good.	Poor.	Total.	Good.	Poor.	Total.
25 per cent +	1	0	1	1.3	0.0	1.3
20 per cent +	2	4	6	2.6	5.3	7.9
15 per cent +	11	13	24	14.5	17.1	31.6
10 per cent +	20	19	39	26.3	25.0	55.3
5 per cent +	30	35	65	39.5	46.0	85.5
1 per cent	36	37	73	47.4	48.7	96.1
1 per cent −	3	0	3	3.9	0.0	3.9
Total	39	37	76			100.0

Deficiency in A. E. is rare in these soils, 3.8 per cent only, and even where the soils are low in A. E. the fertility is not markedly affected, nor is there any correlation of high fertility with high A. E.

In general the A. I. P. in soil did not differ strikingly from the A. E. and practically the same conclusions would be drawn from examination of either set of results, though ammonifications were generally somewhat higher in A. I. P. than in A. E. tests.

A summary of the results is shown in the cuts on page 79.

GENERAL DISCUSSION.

It is clearly evident that the soils examined which included enough samples to be quite representative in this State showed a remarkably low nitrifying power as compared with soils examined and reported by others. The significance of this low nitrification as regards fertility is not known. It has long been believed that nitrate nitrogen is the form of nitrogen most acceptable to plants and in many text books it is even stated that the nitrate is practically the only form in which nitrogen is utilized by the plant.

These views are illustrated in the following quotations from standard works:

"Taking the effectiveness of nitrate soda as 100, that of sulphate of ammonia was 90."[1]

"The nitrates are the chief source of the nitrogen supply of green plants."[2]

" * * * the nitrifying bacteria then oxidizing the ammonia supplying the plant with nitrates according to its requirements."[3]

"The average relative availability of Ammonium Sulphate was 69.7 on all crops for the ten-year period 1898-1907 (taking that of sodium nitrate as 100.)"[4]

"In experiments carried on for twenty-five years to determine the relative effect of different forms of nitrogen, including nitrate of soda

[1]B. Sjollema and J. C. De Ruijter De Wildt. Derstag Lond. Ind. Rijiks, Netherlands, 1907.
[2]Bergen and Davis. Principles of Botany, p. 233.
[3]Franz Lefar. Technical Mycology, Eng. Ed., 1898. Vol. I, p. 382.
[4]E. B. Voorhees and J. G. Lipman, N. J. Sta. Bul. 221.

and ammonium sulphate it was found that during the first two periods each covering five years sulphate of ammonia gave a slightly larger yield. During the last three five-year periods nitrate of soda gave larger yields."[5]

"From the Rothamstead experiments it is found that nitrate of soda affords the better sources of nitrogen for wheat grass and manigolds, the superiority amounting to about 10 per cent, but that for barley, potatoes, and turnips, the two manures are of equal value, nitrogen for nitrogen.

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[5]Thos. F. Hunt, Penn. Sta. Bul. 90

"In the experiments with barley covering a period of fifty years the average of the first thirty years shows 5.6 per cent in favor of nitrates and for the last twenty years an average of .8 per cent in favor of sulphate of ammonia, when supplied in addition with superphosphates and potash. In all the comparative tests when potash was omitted the odds were very much in favor of nitrates.

"For 1900, the twenty-fifth year of a comparative test with manigolds the odds in favor of nitrates were 29.6 tons against 28.2. When used alone nitrate of soda for twenty-seven years has an annual average to its credit of 4.25 tons.

"The average yields of wheat for twenty-two years with nitrates in a complete fertilizer was 28.7 bu. Ammonia with complete fertilizer was 23.4 bu.

"The average of barley for 51 years with

Nitrate in a complete fertilizer was	43.5
Ammonia in a complete fertilizer was	42.1

"The average of marigolds for 27 years with

Nitrate in a complete fertilizer was	18.01 tons.
Ammonia in a complete fertilizer was	14.86 tons."[6]

"Many of the higher green plants prefer their nitrogenous food in the form of nitrates. (Example, nitrate of soda, potassium nitrate.) The fact that this nitrification is going on constantly in soil is of the utmost importance, for while commercial nitrates are often applied to the soil, the nitrates are easily washed from the soil by heavy rains."[7]

"As a fertilizer the special value of nitrate of soda lies in its nitrogen being in a form (nitrate) immediately available as plant food. On the other hand, ammonium sulphate and dried blood will only become available after being acted upon by bacteria which convert their nitrogen into a form absorbable by plants."[8]

Vogel[10] found that the productivity of soils under his investigations bore a direct relation to nitrifying energy.

The last author does not, however, accredit the large returns from any crop when fed ammonia salts to the direct assimilation of the salt itself, but to the changing of the same *to nitrate by nitrification,* which he claims may take place immediately and in enormous amounts. The following quotation illustrates his views:

"This view, however, forgets that if the ammonium salts are to be fed the plant that they must be nitrified. As a nitrogenous manure sulphate of ammonia is practically as effective, nitrogen for nitrogen, as nitrate of soda; it is also to all intents and purposes as rapid in its action, *because the process of nitrification,* which generally precedes the utilization of the ammonia by the plant, takes place very rapidly in suitable soil."

[6]A. D. Hall. Fertilizers and Manures.
[7]Atkinson, College Botany, p. 83.
[8]Report of the Government Bureau of Microbiology for 1909, p. 133. New South Wales.
[10]Vogel Mit de Kais. W. Inst. f. Lond. in Bromberg, B. 2, heft 4, p. 419.

Hall cites the following from Woburn Station as proof. The addition of lime making the conditions suitable for nitrification.

Barley.	*Bushels per Acre.* No Lime.	*Bushels per Acre.* After Liming.
Minerals + Ammonium salts	1.8	23.9
Minerals + Nitrate of soda.....................	24.7	....

"Sulphate of ammonia * * * must be nitrified before the nitrogen is available to plants."[11]

"It is sufficient to emphasize the importance of the process of nitrification to the growing crop. So vital indeed is the subject that successful agriculture may be said to depend largely upon providing proper conditions for rapid nitrification."[12]

"Mention has repeatedly been made of the fact that the plant can make use of the nitrogen only when it is present in the soil in the form of nitrates. * * * All the other materials must undergo the process of nitrification and have their nitrogen converted into nitrates before they can be used by the crop."[13]

"The nitro-bacteria are of great importance in the economy of nature by providing a continual supply of nitrates to the soil."[14]

"The conversion of the ammonia formed during the process of putrefaction into the nitrates is a matter of the greatest importance in soil fertility. * * * A soil to encourage nitrification must, then, have a suitable basis. The question of soil fertility is, then, in its last analysis a bacteriological problem."[15]

"The importance of nitrification will be understood when I say that it is almost exclusively in the form of nitrates that all ordinary farm crops, except legumes, take up their nitrogen.

"I can not here give the details of my researches, but I think my experiments have proved conclusively that not only are the nitrifying bacteria present in abundance, but they are in a state of great activity, and I have been forced to the conclusion that, with the higher temperature in the Transvaal, nitrification proceeds much more rapidly here than in temperate countries.

"I examined some soils which had been kept in 'an air-dry' state in tightly-corked bottles in our laboratories for over five years, and in every case the organisms were found to be present.

"In only two soils in the whole course of my experiments did I fail to find the bacteria in abundance. Both of these were 'vlei' soils, which had probably been in a water-logged state for years, and which contained too much organic matter and too little lime to promote nitrification."[16]

Numerous investigations during recent years have been conducted to determine whether other forms of nitrogen than the nitrate can be used by plants. Typifying these are the following quotations:

[11]John Percival's Agricultural Bacteriology, p. 142.
[12]Vivian, Alfred, First Principles of Soil Fertility, p. 23, 1909.
[13]Vivian, Alfred, First Principles of Soil Fertility, 1909, pages 193, 194.
[14]Pfeffer, Physiology of Plants, Eng. I, 361, 1900.
[15]Frost and MacCampbell, Genl. Bacteriology (1910), p. 288.
[16]Robert C. Watt. Notes from the Chemical Laboratories. Nitrification in Transvaal Soils.

"The recent comprehensive researches of Pitsch and Maze have conclusively proved that the nutritive value of ammonia must not be entirely denied; in the majority of green plants it is second only to nitric acid in value. In the case of some plants, particularly maize and other Graminceal ammonia is by no means of inferior value to nitric acid. Similar results were obtained in cultures of *Brassica* and species of *Allium*. Forest trees also must be dependent on ammonia since nitrates are seldom present in woodland soils. So far as we know at present it is quite certain that in addition to plants which definitely prefer nitric acid, there are others which get along just as well or even better with ammonia."[17]

"Muntz, of the Agricultural Institute of Paris, has demonstrated the falsity of this view (that plants utilize ammonia only after its oxidation and transformation to nitrates.) He grew plants in a soil deprived of nitrates by prolonged leaching and freed from nitrifying ferments by the action of heat. He also took special precautions to prevent the introduction of these ferments during the course of the experiment. The plants were enclosed in glass vessels, and the air supplied to them was conducted through glycerin in order to remove all dust which might carry in the nitrifying germs."[18]

Basing his results on a large number of experiments on paddy rice, both in paddy rice soils and upland soils, M. Nagaoka makes the following conclusions:

"It was sufficiently proved in all of the preceding trials that paddy plants can not utilize nitric nitrogen as well as ammoniacal nitrogen.

"As to the relative value of the nitric and ammoniacal nitrogen upon the paddy rice plant *Juncus* and Arrowhead it is seen that for one hundred of the ammoniacal nitrogen the nitric nitrogen had the following value:

With paddy rice	40
With Juncus	37
With Arrowhead	33"

As to the possibility of the ammoniacal nitrogen being changed into nitrates by the process of nitrification, the author has the following to say:

"However, as a whole in all irrigated soils the so-called process of nitrification does not generally take place * * * hence such conditions of soil might generally be supposed to be provided with ammoniacal nitrogen alone."

As evidence of this may be cited the relatively larger returns from the ammoniacal nitrogen under irrigated conditions than when not irrigated, the latter supposedly being better suited to the process.[19]

Very recently Hutchinson and Miller of the Rothamstead Experiment Station,[20] in a very carefully planned and executed experiment

[17]Ludwig Jost, Lectures on Plant Physiology, 1907, p. 135.
[18]P. P. Deherain. Nitrification in Arable Soil. Exp. Rec., Vol. VI, p. 354.
[19]M. Nagaoka on the Behavior of the Rice Plant to Nitrates and Ammonium Salts. Bull. Tokyo Coll. of Agric., Vol. VI, 1904.
[20]Hutchinson and Miller, Jour. and Agr. Sc., III, 1909.

have clearly demonstrated that wheat can utilize ammonia nitrogen when all possibility of nitrification has been excluded.

From the results of Kruger,[21] showing a difference in different crops as to the form in which they can utilize nitrogen, it would be extremely unsafe to extend Miller's conclusion to any other crop than wheat without experimental demonstration.

Wagner[22] has clearly shown that in field practice nitrate nitrogen produces better yields than ammonia nitrogen.

In these and practically all similar experiments, however, the possibility of nitrification was not excluded and no note of the nitrifying power of the soils was made. No conclusion can therefore be drawn as to whether those plants actually used the ammonia nitrogen or whether it was first converted into nitrate nitrogen by nitrification.

Summarizing present knowledge upon this point, it may be said that it has been definitely shown (1) that some plants can utilize ammonia nitrogen; (2) that there is a difference between plants of different species as to which is the most appropriate form of nitrogen; (3) that in field and pot tests, nitrification not regarded, nitrate nitrogen usually gives larger returns than ammonia nitrogen.

Two points upon which information is sorely needed are:

1. Knowledge of the form of nitrogen best adapted to each species of crop plant.

2. Knowledge as to the necessity of nitrification preliminary to the utilization of ammonia nitrogen by crop plants.

A series of experiments has now been in progress some years which it is hoped may throw light upon these questions.

In all cases, if any such exist, of crops which can not use ammonia nitrogen the ability of the soil to nitrify is essential to crop production. In all cases of crops which can utilize nitrate nitrogen to appreciably better advantage than ammonia nitrogen the ability to nitrify is of value since it increases the return from all organic or ammonia nitrogen applied.

In either of the two above cases the increase of a low to a high N. E. and especially the increase from no appreciable N. E. to an efficient N. E. is an important desideratum.

INCREASING THE N. E. OF SOILS.

The low N. E. of the soils examined may be referred to one of two reasons.

1. The absence of suitable organisms i. e., low N. I. P.

2. Absence of suitable condition for the growth and functioning of the nitrifying organisms, i. e. too low N. C.

Whichever of these conditions actually obtains today it is reasonable to assume that if the soil be made highly suitable to the growth of the nitrifying organisms these organisms will eventually and naturally find their way into those soils.

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[21]Kruger, W. Lander, Jahr 34, 761, 1905.
[22]Wagner, P., Arb. d. Deut. Land Ges. Heft 1[illegible]9, p. 207, (1907)

Kellerman and Robinson[23] have reported higher N. E. in North Carolina soils than our own analyses show either when determined by their method or ours. They were working with soils from fields bearing crimson clover. Crimson clover in North Carolina stands for a high type of farming and without further evidence it is fairly allowable to assume that crimson clover fields in general are attended by good farmers and that the fields are above the average in fertility. Their findings compared with ours, therefore, substantiate the conclusion that the N. E. of soils can be in general increased by good culture. Kellerman and Robinson attach principal importance to legumes and especially to the presence of root tubercles in this connection. Scrutiny of our tables shows the following:

RELATION OF N. E. TO LEGUME CROPS AND TO MANURE USED.

Of 23 soils known to have had a legume growing on them during the past three seasons 7 or 31.43 per cent showed N. E. Five or 18 per cent showed N. E. greater than 2.

Of 14 soils known to have had an application of manure during the past three seasons 6 or 42.85 per cent showed N. E. Two or 14 per cent showed N. E. greater than 2.

Of 52 on which no legume was reported 13 or 25 per cent showed N. E. Three or 5.7 per cent showed N. E. greater than 2.

Of 59 on which no application of manure was reported 14 or 23.81 per cent showed N. E. Six or 10 per cent showed N. E. greater than 2.

It is seen that legume bearing soils do have higher N. E. than non legume bearing soils in the ratio of 31.43 to 25, or N. E. greater than 2 in the ratio of 18 to 5.7.

A similar fact appears regarding the use of stable manure.

Fields with stable manure show N. E. in 42.85 per cent of the cases while fields with no stable manure show N. E. in only 23.81 per cent of the cases or N. E. greater than 2 in 14 per cent as against 10 per cent.

It thus appears that these two factors, legumes and stable manure, are probably of approximately equal value in increasing N. E. The other factors which enter into this question are yet but imperfectly known. Of the inter-relations between the complex bacterial flora we can not even hazard a guess. Whether inoculation with suitable organisms of high nitrifying power would aid in establishing a high N. E. and if so whether the N. E. so attained would be permanent is unknown.

Experiments which have been under way some two years upon these last two points may aid in solving the question.

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[23]Kellerman, K. F., Robinson, T. R., Science Ns. 30 (1909) p. 414.

VI.—STUDIES IN SOIL BACTERIOLOGY

MISCELLANEOUS NITRIFICATION EXPERIMENTS,

BY

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ASSISTED BY

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In the course of a series of investigations extending over a period of several years certain experiments have been made, the results of which, while unrelated and not forming part of the major subject under investigation, still possess some interest and value. It is thought wise to bring these together in the present form.

TO COMPARE THE INHIBITING EFFECT OF AMMONIUM SULPHATE IN SOIL AND IN SOLUTION.

Experiment No. 273. May, 1909.

Six Erlenmeyer flasks were filled with 400 grams of sterile soil 1931 in the usual way with 240 mgs. of nitrogen added as sterile ammonium sulphate solution. To each was added additional sterile ammonium sulphate in the amounts indicated in the table varying from 0 per cent to 5 per cent based upon the total amount of water in the medium.

Six flasks were similarly set up with Omeliansky's solution instead of soil as the medium, these also bearing corresponding amounts of additional ammonium sulphate.

The whole series was also set up to run three months before analysis. All flasks were inoculated in the usual manner with a strongly nitrifying soil (Georgia No. 1). Analyses were made at one month on one series, at three months on the other.

The results are presented in Table I.

The results in solution at the end of the shorter period of incubation, 28 days, are of little value since nitrification was very tardy. Retardation at 28 days is noted in soil in the presence of 0.5 per cent or more "additional" ammonia, in the soil. At the end of twelve weeks decided retardation is evident when there was "additional" ammonia to the amount of 0.5 per cent or more and complete inhibition resulted from the presence of 5 per cent.

In solutions at 12 weeks retardation is evident if amounts of 1 per cent or more "additional ammonia" are present. If the nitrification be based upon the total amount of ammoniacal nitrogen present the same generalizations are maintained though it would then appear as though the retardation were greater in the solutions than in the soils.

No.	Yielding Power Per Acre. Corn, Bu.	Cotton, Lbs.	Other Crop.	Crop Raised. 1909.	1908.	1907.	Fertilizer. 1909.	1908.	1907.	Soil Records. Lab. No. (W)	Assm. No. (S)	Date Collected.	Date Set Up.	Collector.	County.	Quality.	Classification. Collector's.	McNider's.	N. E. 1909.	1910.	N. I. P. in Soil. 1909.	1910.	N. I. P. in Sol. 1909.	1910.	A. E.	A. I. P. in Soil.	A. I. P. in Sol.	No.
1	40	1,800		Peanuts	Cotton	Peanuts	Li. and plas.	*A. and m.	§Li. and plas.	285	255	3- 4-09	3- 8-09	Brown	Hertford	Rich	Loam	N. S. L.		1.8–		72.5–		1.5–	6.03			1
2	15	700		Cotton	Peanuts	Cotton	*A., m. and K.	†L. and p.	Fertilizer	286	256	3- 4-09	3- 8-09	"	"	Poor	Loam	N. S. L.		17.3–		66.5		1.5–	6.49			2
3	40	1,600	?	Carden	Garden	Carden	M. and fert.	F. and m.	M. and fert. ¶	304	259	3-13-09	3-18-09	Stevens	Johnston	Good	N. S. L.	N. S. L.	5.48						15.65			3
4	12	400	?	Cotton	Cotton	Cotton	Fertilizer	Fertilizer	Fertilizer	305	260	3-13-09	3-18-09	"	"	Poor	N. S. L.	N. S. L.							15.89			4
5	59	1,500	40,000 cannas	Vel. beans	Cannas	Cannas	Fert., 500	Fert. 2000	Fert. 2000	309	261	3-17-09	3-22-09	Taylor	Duplin	Cood	N. F. S.	N. F. S.	5.48	6.5	4.74	74.1		1.5–	3.21			5
6	1	109	1,900 cannas	Cannas	Vel. beans	Cannas	Fert. 2009	Fert. 500	Fert. 2900	310	262	3-17-00	3-22-09	"	"	Poor	N. F. S.	N. F. S.		0.5+		23.8		1.5–	1.93			6
7	60	?	High	Corn	Corn	Garden	M.	M.	M.	337	265	3-20-00	4- 5-09	Collett	Buncombe	Rich	Prs. L.	P. L.		21.1		92.1	5.92	0.0	6.23	14.00	17.08	7
8	30	?	10 bu. wheat	Corn	Corn	Wheat	0	0	0	338	206	3-29-09	4- 5-09	"	"	Poor	Prs. L.	P. L.		–0.8				0.0	6.93	14.35	25.61	8
9										350	269	4-10-09	4-15-09	Scott	Edgecombe	Cood	N. S. L.	N. S. L.							10.50	18.55	20.48	9
10										351	270	4-10-09	4-15-09	"	"	Poor	N. S. L.	N. S. L.							12.04	15.40	18.72	19
11	42	1,100	23 bu. wheat	Corn	Cotton	Whent and peas	Fertilizer	Fertilizer	Fertilizer	354	271	4-10-09	4-19-09	Meecham	Iredell	Good	C. C.	C. C.		2.0		41.1	0.38	0.2–	10.80	15.40	19.89	11
12	9	500	2 bu. wheat	Corn	Cotton	Wheat and peas	0	0	0	353	272	4-10-09	4-19-09	"	"	Poor	C. C.	C. C.		1.0–		4.5	0.46	0.2–	6.67	14.53	25.03	12
13	30	1,500	85 bu. peanuts	None	Corn	Peanuts	None	None	L. plas.	360	274	4-22-00	4-26-00	Bachman	Chowan	Cood	N. F. S. L.	N. F. S. L.		0.00		81.4	4.48	0.5	17.95	21.71	14.64	13
14	15	1,000	100 bu. peanuts	None	Cotton	Corn	None	A. & M.	None	361	275	4-22-09	4-26-00	"	"	Poor	N. F. S. L.	N. F. S. L.		0.00		72.4		9.6	15.75	12.05	11.66	14
15	35	1,500		Corn and I. pota.	Cotton	Cotton	Fert. and m.	¶F. and m.	Fert. and m.	376	276	5- 3-09	5- 3-09	Pearce	Duplin	Rich	P. L. S.	N. S. L.		–2.0		7.3–		0.0	15.76	14 35	21.06	15
16	6	300		Corn	Cotton	Corn	Fert. and m.	Fertilizer	Fertilizer	377	277	5- 3-09	5- 3-09	"	"	Poor	P. L. S.	N. F. S.		–1.5–		4.8		0.1–	22.71	14.35	23.40	16
17	23	900	Fine cow peas	Cotton	Corn	Cottou	Fert. 400	Fert. 200	Fert. 400	386	278	5- 5-00	5- 6-00	Drane	Pitt	Good	N. F. S. L.	N. F. S. L.		–7.4–		22.9			14.21	18.50	8.18	17
18	12	600	Cood cow peas	Cotton	Corn	Cotton	Fert. 400	Fert. 200	Fert. 490	387	279	5- 5-09	5- 6-09	"	"	Poor	N. F. S. L.	N. F. S. L.		1.4+		70.9		0.1–	10.53	15.40	19.85	18
19	75	1,500								306	280	5-10-09	5-10-09	Cainey	Wake	Cood	M.	M.		2.2		18.7		1.5–	7.67	19.92	18.65	19
20	50	1,000								397	281	5-10-00	5-10-09	"	"	Poor	M.	M.		13.3–		87.5		1.5–	8.33	18.10	22.50	20
21	23	1,600	1,000 lbs. tob.	Tobacco	Tobacco	Corn	Fert. 1,000	Fert. 1,000	0	401	282	5-12-09	5-13-09	Drane	Pitt	Cood	N. V. F. S. L.	N. V. F. S. L.		–0.3		11.3		0.1–	7.03	20.20	12.40	21
22	12	800	600 lbs. tob.	Corn	Peanuts and mels.	Fallow	0	0	0	402	283	5-12-09	5-13-09	"	"	Poor	N. V. F. S. L.	N. V. F. S. L.		–2.0		28.7		0.1–	6.86	14.67	10.41	22
23	75	1,600								403	284	5-13-09	5-13-09	Cainey	Wake	Good	C. S. L.	C. S. L.		0.09		50.8		1.5–	8.47	11.31	16.03	23
24	25	800								404	285	5-13-09	5-13-00	"	"	Poor	C. S. L.	C. S. L.		0.00		58.2		1.5–	10.22	12.88	21.96	24
25	30	1,500	Good peas	Corn	Peanuts	?	F. 800 and m.	7	?	408	286	5-13-00	5-17-09	Middleton	N. Hanover	Cood	N. S. L.	N. S. L.							0.77	27.31		25
26	Scarcely nothing.			Potatoes	Peanuts	?	M. and f. 600	None	?	409	287	5-13-00	5-17-09	"	"	Poor	N. S. L.	N. S. L.							0.70	44.77		26
27	40	1,500	80 bu. peanuts	0	Cotton	Corn	0	¶Fert. 4,000	0	415	288	5-14-00	6-20-00	Bachman	Perquimans	Cood	P. S. L.	P. F. S. L.							10.15	14.35	24.57	27
28	12	500	50 bu. peanuts	9	Corn	Corn	0	Fish sc.	0	416	289	5-14-09	5-20-09	"	"	Poor	P. S. L.	P. F. S. L.							11.47	14.70	22.17	28
29	75	2,900	High	Beans and pota.	Corn and peas	Corn and peas	Fert 1,000	Fert. 600	Fert. 600	422	290	5-20-09	5-24-09	Ireland	Duplin	Good	O. F. S. L.	O. F. S. L.	16.13	0.00		3.5–		0.1–	15.05	25.59	24.57	29
30	25	1,000	Not very	High-beans	Pota. and corn	Corn and peas	Fert. 1,000	Fert. 600	Fert. 600	423	291	5-20-09	5-24-09	"	"	Poor	O. F. S. L.	O. F. S. L.		3.5–		86.7–		0.1–	23.07	26.26	19.99	30
31	40	900	39 bu. wheat	Corn	Wheat	Clover	F. and m.	F. and m.	0	433	292	5-17-09	5-31-09	Hornaday	Alamance	Good	C. C.	C. C.	39.46	36.1	2.90	78.7	2.00	0.21–	14.28	11.94	19.98	31
32	7	300	5 bu. wheat	Clover past	Wheat	Corn	0	F. and m.	Fert. and m.	434	293	5-17-09	5-31-09	"	"	Poor	C. C.	C. C.	2.00	–11.7–	2.00	54.4	2.00	0.0	6.14	13.51	21.06	32
33			None in cultivation.							435	294	5-10-09	5-31-09	Humphrey	Cravon		Sva.	Sva.							3.46	14.80	22.59	33
34			None in cultivation.							436	295	5-10-09	5-31-09	"	"		Pen.	Pen.							15.75	18.03	16.26	34
35	60	2,000	Good	Beans and cannas	V. beans	Cannas	Fert. 1,500	Fert. 500	Fert. 1,500	440	296	5-22-09	6- 1-09	Taylor	Duplin	Rich	P. S.	P. S.	29.73	10.6	5.20	87.7		1.5–	17.65	22.10	10.65	35
36	1	50	Very poor	Beans and cannas	V. beans	Cannas	Fert. 1,500	Fert 500	Fert. 1,500	441	297	5-22-09	6- 3-09	"	"	Very poor	P. S.	P. S.		0.1	0.10	5.5		1.5–	8.78	10.10	21.99	36
37	35	?	1¼ T. bay	Rye and corn	Rye and beans	Corn	8 tons	Fert. 400	Li. 15 bu.	442	298	5-22-09	6- 3-09	Merchant	Henderson	Rich	Prs. S. L.	Prs. S. L.	2.	1.3+		40.3		0.0	15.68	18.45	24.57	37
38	5	?	½ T. bay	Peas	0	0	0	0	0	443	299	5-22-09	6- 3-09	"	"	Poor	Prs. S. L.	Prs. S. L.		1.6+		6.4		0.0	6.72	10.45	18.72	38
39	15	1,000	15 bu. wheat	Wheat and corn	Wheat and corn	Wheat and corn	Fertilizer	Fertilizer	Fertilizer	450	300	5-27-09	6- 7-09	Moore	Caldwell	Good	Cno. C.	Cno. C. L.		105.1–	0.10	80.7	0.10	0.1–	20.62	25.00	18.98	39
49	10	1,000	5 T. wheat	Wheat	Oats	Corn	Fertilizer	Fertilizer	Fertilizer	451	301	5-27-09	6- 7-09	"	"	Poor	Cno. C.	Cno. S. L.		0.1		30.0	0.10	0.1–	7.53	15.10	15.44	40
41	40	?	?	Corn	Corn	Corn	Lime	Lime	Lime	452	302	5-27-00	6- 7-09	Drane	Pitt	Cood	P. L.	P. L.		–8.0	0.00	30.6		0.1–	16.97	26.43	22.82	41
42	42	1,300	30 bu. oats	Cotton	Cotton	Cotton	Fert. 250	Fert. 500	Fert. 500	453	303	5-27-09	6- 7-09	"	"	Cood	P. S. L.	P. S. L.		0.09	5.05	50.6		0.1–	8.89	16.20	17.78	42
43	22	1,100	30 bu. oats	Oats	Peanuts	Tobacco and peas	0	Fert. 300	Fert. 1,000	459	304	6- 1-09	6-10-09	"	"	Cood	N. S.	N. S.							6.71	13.00	19.89	43
44	8	500	10 bu. oats	Peanuts	Cotton	Corn and peas	Fert. 300	Fert. 800	Fert. 390	460	305	6- 1-09	6-10-09	"	"	Poor	N. S.	N. S.							17.99	21.31	20.47	44
46	28	200	50 bu. rice	0	0	0	0	0	0	461	307	5-22-00	6-10-09	Pritchard	Pasquotank	Medium	Sw.	Sw.							5.36	24.86	15.91	46
47	20	1,500		Corn	Cotton	Cotton	Fertilizer	Fertilizer	Fertilizer	467	308	6- 8-00	6-14-09	Stevens	Wayne	Cood	N. S	N. S.	13.50	0.00		23.2		1.5–	16.71	30.43	29.13	47
48	19	750	Average	0	Corn	Corn	0	0	0	468	399	6- 8-09	6-14-09	"	"	Poor	N. S.	N. S.		0.00		0.9–		1.5–	21.01	21.58	32.41	48
49	20	1,000		Cotton	Cotton					469	310	6- 8-09	6-14-09	Mason	Chowan	Cood	P. St. L.	P. V. F. S.	50.58	–0.7		23.2		0.0	0.03	21.98	21.65	49
50	10	300		Corn						470	311	6- 8-00	6-16-09	"	"	Poor	P. St. L.	P. V F. S.		36.8		80.5		0.0	15.87	25.84	21.06	50
51	45			Corn	Red clover	Wbeat		0	Fertilizer	480	312	6-17-00	6-17-09	Higgins	Buncombe	Cood	Prs. C.	Prs. S. L.	22.4	14.8		30.4		1.5–	5.01	27.66	10.18	51
52	4			Weeds	Corn	Weeds	0	0	0	481	313	6- 8-00	6-17-09	"	"	Poor	Prs. C.	Prs. S. L.		4.0+		5.0		1.5–	11.31	8.40	7.00	52
53	10	600	Medium	Cotton	Cotton	Corn	Fert. 300	Fert. 300	Fert. 200	489	314	6- 7-09	6-21-09	Hall	Wake	Good	S. C. L.	N. C. S. L.		0.5–		10.7		1.5–	14.45	24.51	20.31	53
54	5	300	Very poor	0	0	0	0	0	0	490	315	6- 7-09	6-21-09	"	"	Poor	S. C. L.	N. C. S. L.		0.00		5.8		1.5–	18.37	16.73	18.11	54
55	59			Corn	Crass	Grass	M.	M.	M.	528	321	6-18-00	6-28-09	Hardison	Buncombe	Rich	P. C.	P. C.	.20		60.29				14.52	17.50	25.73	55
56	5			Buckwheat	Corn	Corn	Fert. 400	0	0	529	322	6-18-09	6-28-09	"	"	Poor	P. C.	P. C.	.10		9.00				16.45	19.61	22.82	56
57	30	1,500	40 bu. oats	Sorgbum	Pasture	Pasture	0	0	0	561	323	6- 2-00	7- 5-09	Arey	Iredell	Good	I. C. L.	I. C. L.		19.2–	30.50	73.6	2.0–	1.5–	25.46	39.11	28.08	57
58	10	500	15 bu. oats	0	0	0	0	0	0	560	324	6- 2-00	7- 5-09	"	"	Poor	I. C. L.	I. C. L.		34.2+	5.2–	89.9		1.5–	13.82	25.56	28.08	58
59	20		75 bu. pota.	Corn	Corn	0	0	0	0	551	325	6-10-09	7- 1-09	Ivins	Henderson	Cood	Prs. S.	Prs. S. L.	2.0 –		30.17				4.20	14.70	17.52	59
60	10		40 bu. pota.	Corn	Corn	0	0	0	0	552	326	6-19-09	7- 1-09	"	"	Poor	Prs. S.	Prs. S. L.	1.0 –		2.0–				6.47	22.06	25.73	60
61	25	1,500	20 bu. cow peas	Corn	Corn	Cotton	0	Fertilizer	Fertilizer	571	327	6-10-09	7- 8-09	Chappell	Perquimans	Cood	P. S. L.	P. F. S. L.		9.9	35.86	74.6		0.0	3.50	28.36	21.06	61
62	10	?	12 bu. cow peas	Peas	Corn	0	Fertilizer	0	0	572	328	6-16-09	7- 8-09	"	"	Poor	P. S. L.	P. F. S. L.		0.0		1.3		0.0	6.65	22.06	28.07	62
63										579	329	6-25-09	7-12-09	Long	Alamance	Good	I. C. L.	I. C. L.			69.21		2.0–		2.10	26.26	24.57	63
64										580	330	6-25-00	7-12-09	"	"	Poor	I. C. L.	I. C. L.			40.80				7.70	32.56	25.74	64
65	19	600	1,000 lbs. tob.	Tobacco	Corn	Wheat	Fert. 600	0	0	587	331	7- 3-00	7-15-09	Hall	Cranville	Cood	C. S. L.	C. S. L.	2.	2.2–	60.17–	65.3		0.0	0.88	24.10	26.91	65
66	6	300	600 lbs. tob.	Tobacco	Corn	Wheat	Fert. 600	0	0	588	332	7- 3-09	7-15-09	"	"	Poor	C. S. L.	C. S. L.	2.	–0.1–	4.5	46.0		0.0	20.31	19.95	25.74	66
67	15	500	400 lbs. tob.	Corn	Corn	0	0	0	0	602	334	7- 7-00	7-10-09	Gainey	Cumberland	Good	N. C. S.	N. S.		–1.3	65.80	4.3		0.1–	17.06	9.18	25.74	67
68	1	0	0	Corn	Melons	?	0		?	603	335	7- 7-09	7-19-09	"	"	Poor	N. C. S.	N. S.		0.0	30.70	0.0–		0.1–	15.23	20.41	23.40	68
69	40			Hay stacking place.						012	336	7-10-09	7-22-09	Osborn	Henderson	Cood	T. S. L.	T. S. L.	2.–	17.1	2.0–	32.7		0.0	5.7	18.9	5.8	69
70	10			Corn	Corn	Corn	0	M.	0	613	337	7-18-09	7-22-09	"	"	Poor	T. S. L.	T. S. L.		10.2–	2.0–	17.5		0.0	6.8	22.9	4.7	70
71	40	?	?	Corn	Corn	Corn	Fertilizer	Fertilizer	Fertilizer	022	338	7-20-09	8- 2-09	Collett	Transylvania	Good	T. L.	T. L.		0.0	2.0–	20.4–		9.9	10.68	17.65	9.75	71
72	12	?	?	Corn	Corn	Corn	Fertilizer	Fertilizer	Fertilizer	623	339	7-20-09	8- 2-09	"	"	Poor	T. L.	T. L.	2.–	–2.0	2.0–	52.8		0.0	5.08	22.06	6.75	72
73	25	1,000	1,000 lbs. tob.	Cottou	7	?	?	7	?	624	340	7-21-00	8- 2-09	Cainey	Johnston	Cood	S. C. L.	N. S. L.		12.6+	35.08	6.2		1.5–	7.53	19.25	11.25	73
74	10	300	400 lbs. tob.	0	0	0	0	0	0	625	341	7-21-09	8- 2-00	"	"	Poor	S. G. L.	N. S. L.		0.0	2.0–	0.9–		0.5–	16.65	23.80	6.0	74
75	40	1,500	Good	Peas and lettuce	Corn and peas	Potatoes	Fertilizer	F. and m.	Fertilizer	690	342	7-28-09	8-23-09	Cregerson	N. Hanover	Cood	P. S. L.	P. F. S. L.							1.56	9.71	16.38	75
76	5	500	50 bu. pota.	Potatoes	0	0	F. and m.	0	0	691	343	7-28-09	8-23-09	"	"	Poor	P. S. L.	P. S. L.							1.73	5.17	18.13	76
77	28	1 300		Cotton	Cotton	Cotton	Fertilizer	Fertilizer	Fertilizer	696	344	8- 5-00	8-26-09	Mott	Iredell	Cood	C. S. L.	C. S. L.		2.5	11.50	27.5		0.1–	9.30	21.07	22.23	77
78	2	200		Cotton	Cotton	Cotton	Fertilizer	Fertilizer	Fertilizer	697	345	8- 5-09	8-28-09	"	"	Poor	C. S. L.	C. S. L.		2.9+	3.34	3.9		0.1–	15.75	20.65	27.67	78
79	25	000	8 bu. wheat	Corn	Wheat	Corn	M.	Fertilizer	M.	700	346	8- 6-09	8-30-09	Spoon	Alamance	Cood	C. S.	C. S. L.		2.1–	62.64	29.2		0.0	12.45	21.36	15.21	79
80	15	450	4 bu. wheat	Corn	Rye	Corn	?	0	7	701	347	8- 0-09	8-30-09	"	"	Poor	C. S.	C. S. L.		1.3	43.09	82.6–		0.9	3.40	18.20	8.19	80

*Acid phosphate. †Lime. ‡Stable manure. ¶Commercial fertilizer. §Kalnit.

VI.—STUDIES IN SOIL BACTERIOLOGY

MISCELLANEOUS NITRIFICATION EXPERIMENTS,

BY

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ASSISTED BY

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In the course of a series of investigations extending over a period of several years certain experiments have been made, the results of which, while unrelated and not forming part of the major subject under investigation, still possess some interest and value. It is thought wise to bring these together in the present form.

TO COMPARE THE INHIBITING EFFECT OF AMMONIUM SULPHATE IN SOIL AND IN SOLUTION.

Experiment No. 273. May, 1909.

Six Erlenmeyer flasks were filled with 400 grams of sterile soil 1931 in the usual way with 240 mgs. of nitrogen added as sterile ammonium sulphate solution. To each was added additional sterile ammonium sulphate in the amounts indicated in the table varying from 0 per cent to 5 per cent based upon the total amount of water in the medium.

Six flasks were similarly set up with Omeliansky's solution instead of soil as the medium, these also bearing corresponding amounts of additional ammonium sulphate.

The whole series was also set up to run three months before analysis. All flasks were inoculated in the usual manner with a strongly nitrifying soil (Georgia No. 1). Analyses were made at one month on one series, at three months on the other.

The results are presented in Table I.

The results in solution at the end of the shorter period of incubation, 28 days, are of little value since nitrification was very tardy. Retardation at 28 days is noted in soil in the presence of 0.5 per cent or more "additional" ammonia, in the soil. At the end of twelve weeks decided retardation is evident when there was "additional" ammonia to the amount of 0.5 per cent or more and complete inhibition resulted from the presence of 5 per cent.

In solutions at 12 weeks retardation is evident if amounts of 1 per cent or more "additional ammonia" are present. If the nitrification be based upon the total amount of ammoniacal nitrogen present the same generalizations are maintained though it would then appear as though the retardation were greater in the solutions than in the soils.

Table I—Experiment 273. Inhibiting effect of Ammonium Sulphate in soil and in solution.

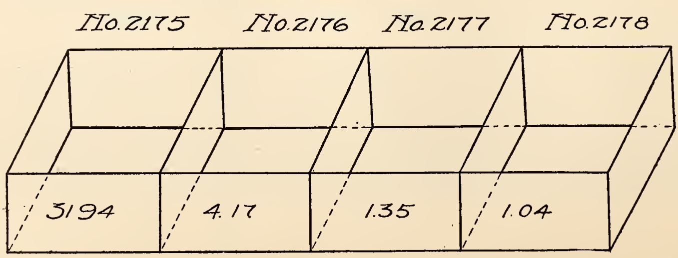
RESULT OF ANALYSIS.

Flask No.	Medium.	Percent of Additional Ammonium Sulphate.	Incubation, Days.	Per Cent Based on Total Initial Nitrogen. Recovered as: Nitrite.	Nitrate.
1	Soil.	0.0	28	0.00	19.42
2	do.	0.01	28	0.00	18.90
3	do.	0.1	28	0.00	14.24
4	do.	0.5	28	0.00	0.00
5	do.	1.0	28	0.00	0.00
6	do.	5.0	28	0.00	0.10
7	Omeliansky's solution.	0.0	28	0.00	0.10
8	do.	0.01	28	0.00	0.10
9	do.	0.1	28	0.00	0.52
10	do.	0.5	28	0.00	0.10
11	do.	1.0	28	0.00	0.10
12	do.	5.0	28	0.00	0.10
13	Soil.	0.0	84	1.00	40.09
14	do.	0.01	84	1.00	37.60
15	do.	0.1	84	1.00	34.18
16	do.	0.5	84	1.00	18.51
17	do.	1.0	84	1.00	1.00
18	do.	5.0	84	1.00	0.00
19	Omeliansky's solution.	0.0	84	1.00	13.86
20	do.	0.01	84	1.00	7.02
21	do.	0.1	84	1.00	8.11
22	do.	0.5	84	1.00	3.81
23	do.	1.0	84	1.00	1.53
24	do.	5.0	84	1.00	1.00

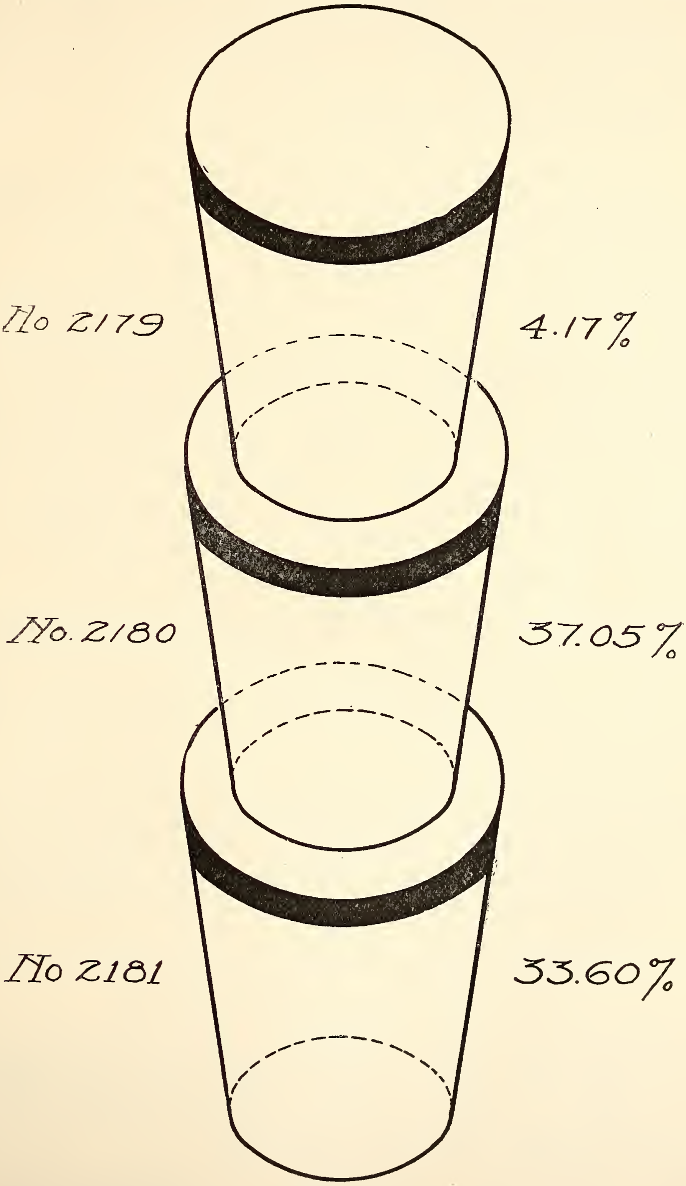
MIGRATION OF NITRIFYING BACTERIA IN SOIL.

Experiment No. 79. February 24, 1908.

To test horizontal migration a series of four samples of soil No. 1867, identical except for the inoculum added, was set up as is shown in the accompanying diagram, the four samples being included in a tight, rectangular oak box with open top. The partitions between the several



compartments were of rather coarse iron gauze. The samples were so packed in the compartments as to bring the soil in one compartment closely in contact with the soil of the adjacent compartment. Each lot



of soil contained 240 mgs. nitrogen as ammonium sulphate. The soil in compartment No. 2175 was thoroughly inoculated with a suspension taken from a vigorously nitrifying soil. Lots 2176, 2177, and 2178 were not inoculated. Analysis was made at the end of eight weeks. The results are presented in table 2.

To test vertical migration three flower pots were taken and placed one above the other. In each was placed the same amount of soil initial nitrogen and there was the same incubation period as in the experiment to test horizontal migration, only 2179 was inoculated with 25 cc. of a suspension of soil 1867.

The results are shown in Table II.

TABLE II.—EXPERIMENT 79.

Date of inoculation, Feb. 24, 1908. Time of incubation, 56 days. Medium, 400 grams sterile soil No. 1867. Nitrogen. 240 milligrams in form of ammonium sulphate.

HORIZONTAL MIGRATION.

Sample Number.	Inoculum, kind.	Quantity.	Percentage of initial nitrogen recovered as:		
			Ammonia.	Nitrite.	Nitrate.
2175	Suspension 1867	25cc	25.91	0.00	31.94
2176	Only from 2175	------------	37.11	0.00	4.17
2177	do. 2176	------------	31.44	0.00	1.35
2178	do. 2177	------------	32.91	0.00	1.04—

VERTICAL MIGRATION.

2179	Suspension 1867	25cc	13.30	0.00	4.17
2180	Only from 2179	25cc	34.22	0.00	37.05
2181	do. 2180	25cc	39.91	0.00	33.60

It is seen that within the duration of the experiment there was little, possibly no, migration of the nitrifying organisms from one compartment to another, the small amount of nitrate that passed to the lateral or lower compartments being perhaps more readily explained on the basis of diffusion of nitrate than on the hypothesis of germ migration.

EFFECT OF DRYING UPON N. E. AND N. I. P.

Experiments 252 and 253. May, 1909.

Two soils, No. 1867 and Georgia No. 1 were tested for N. E. and N. I. P. in the usual way except that no subtraction was made for the control sample in any case. Other samples of the same soils were allowed to air dry in the laboratory for two months and N. E. and N. I. P. were determined in them in the usual way.

Table III shows the N. E. and N. I. P. in the fresh and air dried samples.

It is seen that the two months of drying resulted in no material change in the N. E. of either of these soils. The N. I. P., however, did

TABLE III.—EXPERIMENTS 252 AND 253.

	Soil 1867.		Georgia Soil No. 1.	
	Before Drying.	Dried.	Before Drying.	Dried.
N. E.	67.02 72.03	59.82 61.08	22.55 16.91	18.79 21.92
Average	69.53	60.45	19.73	20.36
N. I. P.	68.90 66.40	8.77 9.40	47.29 41.37	0.00 0.00
Average	67.65	9.09	44.33	0.00

change very materially, dropping in the case of the N. C. soil from 67 to 9 and in the case of the Ga. soil from 44 to zero. The discrepancy between the N. E. and N. I. P., fully sustained as it is by the duplicate samples is peculiar and unexpected.

FURTHER EVIDENCE OF DIFFERENCE BETWEEN N. I. P. IN SOIL AND IN SOLUTION.

Experiment No. 264. April, 1909.

The N. I. P. of Georgia soil No. 1 was determined both in soil and in solution with the following results.

TABLE IV.—N. I. P. OF GEORGIA SOIL NO. 1.

	Sample No.	Percentage of initial nitrogen recovered as:		
		Nitrites.	Nitrates.	Nitrites and Nitrates.
In soil	3729 3730 aver. 3731 net	0.00 0.00 0.00 0.00 0.00	12.53 10.65 11.59 0.00 11.59	12.53 10.65 11.59 0.00 11.59
In solution	3732 3733 aver. 3734 net	tr. 3.50 1.75 0.00 1.75	1.91 2.40 2.16 0.00 2.16	1.91 5.90 3.91 0.00 3.91

It is to be noted that the N. I. P. while agreeing well in the duplicate samples is far lower when determined in solutions than when determined in soils.

A COMPARISON OF THE METHOD OF KELLERMAN AND ROBINSON WITH THE STEVENS AND WITHERS METHOD OF DETERMINING NITRIFYING POWER.

Experiment No. 349. October, 1909.

For this purpose nineteen soils were selected. Four soils were known to bear cowpeas with root tubercles, four crimson clover with tubercles, four vetch with tubercles. Four we had already determined by our own method as low in nitrifying power, while three were on our record as good nitrifyers.

To determine the nitrifying ability of several soils using the method of Kellerman and Robinson, i. e.: to 50 grams of soil exposed to air in inoculating room to dry were added 5 cc. of a 0.4 per cent solution of ammonium sulphate, placed in sterile wide mouth bottles stopped with wet cotton plug and incubated for eight days, September 30 to October 7, 1909. Done in duplicate, one analysed in 0 days. Difference between 0 days and 8 days nitrification. The results are shown in Table V.

Table V.—Nitrification. Kellerman and Robinson Method.

	Soil No.		Parts per Million Nitrate Nitrogen.			
			0 Days.	8 Days.	Net.	Average.
6081–2	1 Soil A	Cowpea tubercules present.	2.0—	25.8	23.8	
6083–4	2 Soil B	do.	2.0—	11.0	9.0	
6085–6	3 Soil C	do.	2.0—	9.0	7.0	
6087–8	4 Soil D	do.	2.0—	9.0	7.0	11.7
6089–90	5 Soil E	Crimson clover tubercules.	2.0—	10.5	8.5	
6091–2	6 Soil F	do.	2.0—	9.5	7.5	
6093–4	7 Soil G	do.	2.0—	16.0	14.0	
6095–6	8 Soil H	do.	4.0	26.0	22.0	13.0
6097–8	9 Soil I	Vetch tubercules present.	4.0	25.1	21.1	
6099–00	10 Soil J	do.	2.0—	15.0	13.0	
6101–2	11 Soil K	do.	2.0—	9.0	7.0	
6103–4	12 Soil L	do.	5.0	5.0	0.0	10.3
6105–6	13 Soil 311	Soil Sur. non-nitrifying.	9.0	12.0	3.0	
6107–8	14 Soil 314	do.	5.0	12.5	7.5	
6109–10	15 Soil 315	do.	5.0	14.0	9.0	
6111–12	16 Soil 279	do.	12.0	17.5	5.5	6.2
6113–4	17 Soil 290	Soil Survey nitrifying.	40.0	42.2	2.2	
6115–6	18 Soil 308	do.	23.5	50.0	26.5	
6117–8	19 Soil 310	do.	4.0	228.5	224.5	63.3

The nitrates were determined by the phenol disulphonic acid method. l. c.

It is to be noted that in general the results agree; the soils reported low by one method are shown to be low by the other method though in the Kellerman and Robinson method only one soil gave zero.

Though the samples are not of sufficient number to admit of generalization these results indicate superior nitrifying power in soil that bears tuberculous crops.

Experiment 350, Nitrification. Stevens and Withers Method.

Incubated 4 weeks (Sept. 30 to October 28, 1909). Eleven of the 19 soils used in experiment 349 were used in this experiment and an additional soil (332). The results (N. E.) are shown in Table VI.

TABLE VI.—EXPERIMENT 350, NITRIFICATION.

Lab. No.	Soil No.		Parts per Million Parts of Soil.			Per Cent of Initial N.		
			NO_2	NO_3	NO_2 & NO_3	NO_2	NO_3	NO_2 & NO_3
6143	1 E	Crimson clover tubercles present.	0.0	40.0	40.0	0.0	1.50	1.5
6144	2 E	do.	5.4—	40.0	45.4	0.28	1.50	1.78
Aver.			2.7—	40.0	42.7	0.14	1.50	1.64
6145	3 E	No Am. S. added.	2.0—	3.6	5.6	0.1—	0.13	0.23—
6146	4 E	do.	0.0	4.8	4.8	0.0	0.18	0.18
Aver.		do.	1.0—	4.2	5.2	0.05	0.16	0.21—
Net-N. E.			1.7	35.8	37.5	0.09	1.34	1.42
6147	5 F	Crimson clover tubercles present.	6.0	3.0	9.0	0.30	0.11	0.41
6148	6 F	do.	2.0—	0.0	2.0	0.1—	0.00	0.10—
Aver.			4.0—	1.5	5.5—	0.2—	0.06	0.26—
6149	7 F	No Am. S. added.	0.0	6.0	6.0	0.0	0.23	0.23
6150	8 F	do.	0.0	4.8	4.8	0.0	0.18	0.18
Aver.			0.0	5.4	5.4	0.0	0.21	0.21
Net-N.E.			4.0—	3.9—	0.1—	0.2—	—0.15	0.05—
6151	9 G	Crimson clover tubercles present.	3.5	60.0	63.5	0.18	2.26	2.34
6152	10 G	do.	4.0	48.0	52.0	0.20	1.81	2.01
Aver.			3.8	54.0	57.8	0.19	2.04	2.23
6153	11 G	No Am. S. added.	2.0—	6.0	8.0—	0.10—	0.23	0.33
6154	12 G	do.	2.0—	2.4	4.4—	0.10—	0.09	0.19
Aver.			2.0—	4.2	6.2—	0.10—	0.16	0.26
Net-N. E.			1.8+	49.8	51.6	0.09+	1.88	1.97
6155	13 H	Crimson clover turbercles present.	2.0—	96.0	98.0—	0.10—	3.62	3.72—
6156	14 H	do.	2.0—	96.0	98.0—	0.10—	3.62	3.72—
Aver.			2.0—	96.0	98.0—	0.10—	3.62	3.72—
6157	15 H	No Am. S. added.	2.0—	30.0	32.0—	0.10—	1.13	1.23—
6158	16 H	do.	2.0—	30.0	32.0—	0.10—	1.13	1.23—
Aver.			2.0—	30.0	32.0—	0.10—	1.13	1.23—
Net-N.E.			0.0	66.0	66.0	0.0	2.49	2.49
6159	17 290	Survey nitrifying.	2.0—	240.0	242.0—	0.1—	9.04	9.14—
6160	19 290	No Am. S. added.	2.0—	159.8	161.8	0.1—	6.00	6.10—
Net-N. E.			0.0	80.2	80.2	0.0	3.04	3.04
6161	21 308	Survey nitrifying.	66.6	75.0	141.6	3.33	2.83	6.16
6162	22 308	do.	40.0	120.0	160.0	2.00	3.55	5.55
Aver.			53.3	97.5	150.8	2.67	3.19	6.86
6163	23 308	No Am. S. added.	50.0	7.5	57.5	2.50	0.28	2.78
6164	24 308	do.	28.0	8.6	36.6	1.40	0.23	1.63
Aver.			39.0	8.1	47.1	1.95	0.26	2.21
Net-N.E.			11.3	89.4	100.7	0.72	2.93	3.65

Table VI.—Experiment 350, Nitrification—*Continued.*

Lab. No.	Soil No.		Parts per Million Parts of Soil.			Per Cent of Initial N.		
			NO_2	NO_3	NO_2 & NO_3	NO_2	NO_3	NO_2 & NO_3
6165	25 310	Survey nitrifying.	80.0	300.0	380.0	4.0	11.36	15.36
6166	27 310	No Am. S. added.	2.0—	4.8	6.8—	0.1—	0.18	0.28—
Net-N. E.			78.0+	295.2	373.2+	3.9+	11.18	15.08
6167	29 332	Survey nitrifying.	0.0	60.0	60.0	0.00	2.27	2.27
6168	30 332	do.	0.0	30.0	30.0	0.00	1.13	1.13
Aver.			0.0	45.0	45.0	0.00	1.70	1.70
6169	31 332	No Am. S. added.	0.0	48.0	48.0	0.00	1.81	1.81
6170	32 332	do.	0.0	34.2	34.2	0.00	1.29	1.29
Aver.			0.0	41.1	41.1	0.00	1.55	1.55
Net-N. E.			0.0	3.9	3.9	0.00	0.15	0.15
6171	33 311	Survey non-nitrifying.	0.0	60.0	60.0	0.00	2.26	2.26
6172	34 311	do.	0.0	24.0	24.0	0.00	0.90	0.90
Aver.			0.0	42.0	42.0	0.00	1.58	1.58
6173	35 311	No Am. S. added.	0.0	60.0	60.0	0.00	2.26	2.26
6174	36 311	do.	0.0	48.0	48.0	0.00	1.81	1.81
Aver.			0.0	54.0	54.0	0.00	2.04	--------
Net-N. E.			0.0	—12.0	—12.0	0.00	—0.46	—0.46
6175	37 314	Survey non-nitrifying.	2.0—	96.0	98.0—	0.10—	3.62	3.72—
6176	38 314	do.	2.0—	6.0	8.0—	0.10—	0.23	0.33—
Aver.			2.0—	51.0	53.0—	0.10—	1.98	2.08—
6177	39 314	No Am. S. added.	2.0—	20.0	22.0—	0.10—	0.75	0.85—
6178	40 314	do.	2.0—	12.0	14.0—	0.10—	0.45	0.55—
Aver.			2.0—	16.0	18.0—	0.10—	0.60	0.70—
Net-N. E.			0.0	35.0	35.0	0.00	1.38	1.38
6179	41 315	Survey non-nitrifying.	0.0	4.8	4.8	0.00	0.18	0.18
6180	42 315	do.	0.0	7.2	7.2	0.00	0.27	0.27
Aver.			0.0	6.0	6.0	0.00	0.23	0.23
6181	43 315	No Am. S. added.	0.0	24.0	24.0	0.00	0.90	0.90
6182	44 315	do.	0.0	12.0	12.0	0.00	0.45	0.45
Aver.			0.0	18.0	18.0	0.00	0.68	0.68
Net-N. E.			0.0	—12.0	—12.0	0.00	—0.45	—0.45
6183	45 279	Survey non-nitrifying.	2.0—	48.0	50.0—	0.10—	1.80	1.90
6184	46 279	do.	40.0	60.0	100.0	2.00	2.26	4.26
Aver.			21.0—	54.0	75.0—	1.05—	2.03	3.08
6185	47 279	No Am. S. added.	0.0	34.2	34.2	0.00	1.29	1.29
Net-N. E.			21.0—	19.8	40.8—	1.05	0.74	1.79

Note: Phenol disulphonic acid method was used for these determinations. l. c.

Note: The averages of N. E. are:

Crimson clover -- 4.48
Survey nitrifying -- 5.48
Survey non-nitrifying -- 0.57

Tabulating the net results of Tables V and VI for purposes of comparison we have Table VII.

TABLE VII.—Parts per million parts of soil.

Soil No.	8 Days NO_3*	Rank.	4 Weeks NO_3	Rank.	4 Weeks NO_2 & NO_3†	Rank.
E	8.5	6	35.8	6	37.2	7
F	7.5	7-8	—3.9	11-12	0.1	10
G	14.0	4	49.8	5	51.6	5
H	22.0	3	66.0	4	66.	4
290	2.2	11	80.2	3	80.2	3
308	26.5	2	89.4	2	100.7	2
310	224.5	1	295.2	1	373.2	1
332	—45.1	12	3.9	11-12	309.	9
311	3.0	10	—12.0	9-10	—12.	11-12
314	7.5	7-8	35.0	7	35.	8
315	9.0	5	—12.0	9-10	—12.	11-12
279	5.5	9	19.8	8	40.8	6

*Stevens and Withers N. E. method.
†Kellerman and Robinson method.

Comparing the rank of the soils regarding nitrates at eight days and at four weeks it is noted that six soils have different rank at these intervals with the additional time of the four-week period. One soil, No. 90, has changed its rank from 11 to 3. The change made by soils Nos. G and H 279 is insignificant. Soil F is reduced from a rank of 7 to that of 11. Soil 315 from 5th rank to 10th rank.

It is apparent from this that a comparison of the nitrates accumulated in a soil at the end of one time interval can not be used as an index of the amount that might be produced in the soil in some other time interval, though in general there is a fairly good agreement between the ranks of the soils at the end of the eight day and the four week intervals. As might be expected there are other changes in rank if the comparison be based on nitrate at the eight day interval and the nitrate and nitrite at the four week interval, which is really a comparison of the results by the method of Kellerman and Robinson with our N. E. method. For example, two changes in rank from 7-8 to 10, 279 changes from 9 to 6, 290 from 11 to 3, and 332 from 12 to 9.

TO DETERMINE THE DIFFERENT EFFECTS ON NITRIFICATION OF VARIOUS AMOUNTS OF AMMONIUM SULPHATE IN SOIL.

Experiment 352, January 13, 1910, and Experiment 463, March 2, 1911.

To determine the relation of nitrification to amount of ammonium sulphate added, when used both in smaller and larger quantities than 240 mg. nitrogen per 400 grams of soil. Sterile soil 1931 and nitrogen in varying amounts and 75 cc. suspension of Georgia soil No. 1 as inoculum were used, and incubated four weeks. Results are shown in Table VIII.

TABLE VIII.—A comparison of the results using different amounts of initial added nitrogen.

EXPERIMENT 352.

Lab. No.	Mgs. N. as Am. S.	Pts. N. P. M. Recovered as:			Per cent. Initial added N. recovered as:
		NO_2	NO_3	NO_2 & NO_3	NO_2 & NO_3
6333	2	0.45	48.39	----------------	
6334	2	0.45	40.89	----------------	
Aver.		0.45	44.64	45.09	
6347–48	0	2.19	54.21	56.40	
Net.		—1.74	—9.57	—11.31	—226.2
6335	20	0.45	86.00	----------------	
6336	20	0.45	78.50	----------------	
Aver.		0.45	82.25	82.70	
6347–48	0	2.19	54.21	56.40	
Net.	0	—1.74	28.04	26.30—	52.6
6337	60	0.45	157.35	----------------	
6338	60	0.45	161.10	----------------	
Aver.		0.45	159.23	159.68	
6347–48	0	2.19	54.21	56.40	
Net.		—1.74	105.02	103.28—	68.3
6339	120	0.45	366.00	----------------	
6340	120	0.45	33.90	----------------	
Aver.		0.45	349.95	350.40	
6347–48	0	2.19	54.21	56.40	
Net.		—1.74	295.74	294.00—	96.9
6341	240	2.34	476.40	----------------	
6342	240	2.25	492.60	----------------	
Aver.		2.30	484.50	486.80	
6347–48	0	2.19	54.21	56.40	
Net.		0.11	430.29	430.40—	75.2
6343	480	12.84	560.40	----------------	
6344	480	18.00	223.00	----------------	
Aver.		15.42	391.80	407.22	
6347–48	0	2.19	54.21	56.40	
Net.		13.23	337.59	350.82—	29.3
6345	960	5.52	21.60	----------------	
6346	960	4.56	494.20	----------------	
Aver.		5.04	258.00	263.04	
6347–48	0	2.19	54.21	56.40	
Net.		2.85	203.79	206.64—	8.7
6347	0	3.18	53.22	----------------	
6348	0	1.20	55.20	----------------	
Aver.		2.19	54.21	56.40	
(1) 6343	Duplicate	----------------	556.80	----------------	
(2) 6344	do.	----------------	211.2	----------------	
(3) 6345	do.	----------------	31.2	----------------	
(4) 6346	do.	----------------	465.6	----------------	

EXPERIMENT 463.

Lab. No.	Mgs. N. as Am. S.	Parts N. per Million Parts Soil as:			
		NO_2	NO_3	NO_2 & NO_3	Net. NO_2 & NO_3
7729		0.9—	4.0		
7730		0.9—	4.0		
Aver.	0 Mgs. N. as Am. S.	0.9—	4.0	4.9—	
7715		0.9—	9.4		
7716		0.9—	8.8		
Aver.	2 Mgs. N. as Am. S.	0.9—	9.2	10.1—	
7729–30				4.9—	
	Nitrification				5.2
7717		0.9—	4.0		
7718		0.9—	4.6		
Aver.	20 Mgs. N. as Am. S.	0.9—	4.3	5.2—	
7729–30				4.9—	
	Nitrification				0.3
7719		0.9—	11.0		
7720		0.9—	11.0		
Aver.	60 Mgs. N. as Am. S.	0.9—	11.0	11.9—	
7729–30				4.9—	
	Nitrification				7.0
7721		0.9—	22.0		
7722		Not	received.		
Aver.	120 Mgs. N. as Am. S.	0.9—	22.0	22.9—	
7729–30				4.9—	
	Nitrification				18.0
7723		0.9—	9.4		
7724		0.9—	8.5		
Aver.	240 Mgs. N. as Am. S.	0.9—	8.9	9.8—	
7729–30				4.9—	
	Nitrification				4.9
7725		0.9—	4.0		
7726		0.9—	2.6		
Aver.	480 Mgs. N. as Am. S.	0.9—	3.3	4.2—	
7729–30				4.9—	
	Nitrification				—0.7
7727		0.9—	3.3		
7728		0.9—	3.3		
Aver.	960 Mgs. N. as Am. S.	0.9—	3.3	4.2—	
7729–30				4.9—	
	Nitrification				—0.7

In experiment 352 the greatest nitrification was when ammoniacal nitrogen was added to 400 grms. of soil to the amount of 240 milligrams at the beginning. This is equivalent to 600 parts per million of soil. 480 milligrams of ammoniacal nitrogen gave the next greatest nitrification and 120 milligrams next. But the greatest nitrification based upon per cent of initial added nitrogen was when 120 milligrams nitrogen were added at the beginning. This corresponds to 300 parts of added nitrogen per million parts of soil or 300 milligrams to 1 kilogram.

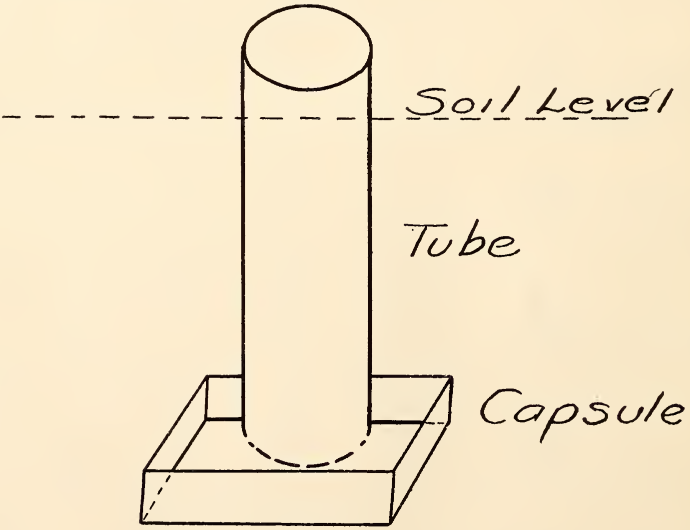
In experiment 463 the nitrification was small in all cases, but was greatest when there was 120 milligrams of added initial nitrogen. The percentages were small in each case.

The two experiments together would indicate 120 milligrams of nitrogen as the preferable amount in the soils used.

TO DETERMINE THE RELATIVE N. E. OF SOILS AS MEASURED BY TESTS IN FLASKS IN THE INCUBATOR ROOM; IN FLASKS BURIED IN THE SOIL IN THE FIELD, AND IN TUBES SIMILARLY BURIED.

Experiment 374. May, 1910.

The soil samples were made up in the usual way. One set of flasks, however, was buried in the plats, being set in the ground so deeply that only a few centimeters of the neck protruded. The tubes used were of special construction of heavy annealed glass 18 cm. long, 6 cm. in diameter, the bottom being perforated by holes, each 2 mm. in diameter. These tubes were set in glass capsules of appropriate size so as to catch any drainage water that might percolate through. This water was included in the analyses.



Both the buried tubes and buried flasks were protected from rain by glass covers.

Two soils were tested thus, every determination being made in duplicate.

TABLE IX.—EXPERIMENT 374.

RELATIVE N. E. OF SOILS BY VARIOUS METHODS.

Lab. No.		Per Cent. N as: NO$_2$	NO$_3$	NO$_2$ and NO$_3$	
6797	Sterile 1931 and 240 mgs. N. as Am. S. Incubated flask.	0.4	79.2	--------	
6798	" 240 " "	0.1—	78.6	--------	
Aver.		0.3—	78.9	79.2—	
6795	" 0 " "	0.1—	8.8	--------	
6796	" 0 " "	Not	rec'd.		
Aver.		0.1—	8.8	8.9—	
Net N.E.	(Incubated flask)	--------	--------	--------	70.3
6801	1931 and 240 mgs. N. as Am. S. Buried flask.	0.7	20.6	--------	
6802	" 240 " "	0.8	21.1	--------	
Aver.		0.8	20.9	21.77	
6799	" 0 " "	0.6	3.2	--------	
6800	" 0 " "	0.3	3.0—	--------	
Aver.		0.5	3.1—	3.6—	
Net N.E.	(Buried flask)	--------	--------	--------	18.1
6805	1931 and 240 mgs. N. as Am. S. Buried tube.	0.9	18.5	--------	
6806	" 240 " "	0.9	14.5	--------	
Aver.		0.9	16.5	17.4	
6803	" 0 " "	--------	--------	1.0—	
6804	" 0 " "	--------	--------	1.0—	
Aver.		--------	--------	1.0—	
Net N.E.	(Buried tube)	--------	--------	--------	16.4
6809	Soil plat 4 and 240 mgs. N. as Am. S. Incubated flask.	0.0	37.0	--------	
6810	" 240 " "	0.0	34.5	--------	
Aver.		0.0	35.8	35.8	
6807	" 0 " "	0.1—	3.0—	--------	
6808	" 0 " "	0.4	3.0—	--------	
Aver.		0.3—	3.0—	3.3—	
Net N.E.	(Incubated flask)	--------	--------	--------	32.5
6813	Soil plat 4 and 240 mgs. N. as Am. S. Buried flask.	0.1—	21.9	--------	
6814	" 240 " "	0.0	27.5	--------	
Aver.		0.1—	24.7	24.8	
6811	" 0 " "	--------	--------	1.0—	
6812	" 0 " "	--------	--------	1.0—	
Aver.		--------	--------	1.0—	
Net N.E.	(Buried flask)	--------	--------	--------	23.8
6817	Soil plat 4 and 240 mgs. N. as Am. S. Buried flask.	0.0	16.6	--------	
6818	" 240 " "	0.0	15.0	--------	
Aver.		0.0	15.8	15.8	
6813	" 0 " "	--------	--------	1.0—	
6816	" 0 " "	--------	--------	1.0—	
Aver.		--------	--------	1.0—	
Net N.E.	(Buried tube)	--------	--------	--------	16.8

It is seen that the incubation room flasks gave a much higher N. E. than the buried flasks, and similarly that the N. E. as shown in the buried flasks was somewhat higher than in the buried tubes. This conclusion is the same whether we regard the net N. E. or the nitrate nitrogen formed from the nitrogenous material orginally present in the soil or the total nitrate formed in the cultures at the end of the experiment. It appears, moreover, that the temperature of the incubation room caused greater acceleration of nitrification in the case of soil 1931 than it did in the case of soil from plat 4, as shown by the ratio 70:32 though when tested by the buried tube method the N. E. is found to be practically equal in the two soils.

These facts are interesting since they show that even the change of the condition from the field to the incubation room may cause two soils of apparently equal field nitrifying power to show large differences in laboratory nitrifying power.

From such facts it becomes obvious that soil tests in order to give us knowledge of the phenomena as they occur in the field must be made under conditions of the field.

TO STUDY THE EFFECT OF ADDING LIME, COW MANURE AND A VIGOROUS NITRIFYING SOIL TO SOIL 1931 IN VARIOUS PROPORTIONS.

Experiment 357, Parts 1, 2, 3, 4, and 5. December 20, 1909, to April 11, 1910.

Plats .0001 of an acre in the experiment ground were employed. Also one plat indoors made on the concrete floor in the basement of the agricultural building.

To make the outdoor plats, pits were dug in a still impervious red clay soil (Cecil clay) and board boxes without bottoms, inside dimensions 26x24x8 inches were set in these pits, the edges projecting a few inches above the surrounding soil. Red clay was tightly tamped around these frames and in the bottom so that the pits could receive the experimental soil to a depth of about six inches, and with an area of .0001 acre (4 sq. ft.).

The soils for the several plats were prepared as follows:

In each case where soil 1931 is referred to it was sifted through a 5 mesh screen to remove stones and roots, etc., and was then mixed thoroughly.

Plat 1 consisted of soil 1931 with lime (CaO) added at the rate of 1000 pounds per acre, or approximately 40 gms. per plat.

Plat 2 was the same as Plat 1, except that cow manure was added at the rate of 20 tons per acre, or 4 pounds per plat. This was as taken from barn.

Plat 3 was identical with Plat 2, except that a vigorously nitrifying soil (Georgia soil No. 1) was added at the rate of 300 pounds per acre.

Plat 4 was like Plat 3, except that Georgia soil No. 1 was added at the rate of 5 tons per acre.

Plat 5. This plat was made 2′10″x6′4″ in size on the concrete floor in the basement of the agricultural building by running in board boundaries 8.5″ high. The soil placed in this area to a depth of 7 inches consisted of soil 1931 with cow manure and Georgia soil No. 1 and lime thoroughly mixed.

Determinations of N. E. were made in the usual way[1] in each plat at the beginning and subsequent determinations at the end of two weeks, one, two, and three months.

One error unavoidable in such work is that incident to imperfect sampling, an error likely to be appreciable, especially in the plats bearing the cow manure. Some slight discrepancies in the results are doubtless attributable to this cause. The details of the results are presented in Table X and a summary is found in Table XI.

TABLE X.—EXPERIMENT 357. Showing effect on N. E. of adding various substances 400 grams live soil No. 1931.

PART 1—Mixture standing no weeks.

Lab. No.	Plat No.	Mgs. N. as Am. S.	Percentage of Initial Added N. Recovered as:			N. E.
			NO_2	NO_3	NO_2 and NO_3	
6350	1	240	0.2—	1.0—		
6351	1	240	0.2—	1.0—		
Aver.	1		0.2—	1.0—	1.2—	
6352	1	0	0.2—	1.0—		
6353	1	0	0.2—	1.0—		
Aver.	1		0.2—	1.0—	1.2—	
Net N. E.		(Lime)				0.0
6354	2	240	0.2—	1.0—		
6355	2	240	0.2—	1.0—		
Aver.	2		0.2—	1.0—	1.2—	
6356	2	0	0.0	0.0		
6357	2	0	0.0	0.0		
Aver.	2		0.0	0.0	0.0	
Net N. E.	(Lime and cow manure)					1.2—
6358	3	240	0.2—	1.0—		
6359	3	240	0.2—	1.0—		
Aver.	3		0.2—	1.0—	1.2—	
6360	3	0	0.2—	1.0—		
6361	3	0	Not rec'd.			
Aver.	3		0.2—	1.0—	1.2—	
Net N. E.	(Lime, cow manure and inoculated by Georgia soil No. 1)					0.0
6362	4	240	0.2—	1.0—		
6363	4	240	0.2—	1.0—		
Aver.	4		0.2—	1.0—	1.2—	
6364	4	0	0.2—	1.0—		
6365	4	0	0.2—	1.0—		
Aver.	4		0.2—	1.0—	1.2—	
Net N. E.	(Lime, cow manure and inoculated by Georgia soil No. 1)					0.0
6366	5	240	0.2—	1.0		
6367	5	240	0.2—	1.0		
Aver.	5		0.2—	1.0	1.2—	
6368	5	0	0.0	0.0		
6369	5	0	0.0	0.0		
Aver.	5		0.0	0.0	0.0	
Net N. E.	(Indoor plat)					1.2—

[1]Stevens, F. L., and Withers, W. A., Cent. f. Bak., II Abt. Bd. 34, 187–203.

TABLE X—Continued.

PART 2.—Mixtures standing 2 weeks.

Lab. No.	Plat No.	Mgs. N. as. Am. S.	Percentage of Initial Added N. Recovered as: NO_2	NO_3	NO_2 and NO_3	N. E.
6376	1	240	0.2—	18.07		
6377	1	240	0.2—	15.4		
Aver.	1		0.2—	16.7	16.9—	
6378	1	0	0.2—	3.0—		
6379	1	0	0.2—	3.0—		
Aver.	1		0.2—	3.0—	3.2	
Net N. E.	(Lime)					13.7
6380	2	240	0.2—	16.1		
6381	2	240	0.2—	14.2		
Aver.	2		0.2—	15.2	15.4	
6382	2	0	0.2—	3.0—		
6383	2	0	0.2—	3.0—		
Aver.	2		0.2—	3.0—	3.2—	
Net N. E.	(Lime and manure)					12.2
6384	3	240	0.2—	11.1		
6385	3	240	0.2—	12.3		
Aver.	3		0.2—	—11.7	11.9	
6386	3	0	0.2—	16.7		
6387	3	0	0.2—	19.2		
Aver.	3		0.2—	18.0	18.2	
Net N. E.	(Lime, manure and Georgia soil, No. 1)					—6.3*
6388	4	240	0.2—	35.8		
6389	4	240	0.2—	36.8		
Aver.	4		0.2—	36.3	36.5	
6390	4	0	0.2—	7.3		
6391	4	0	0.2—	3.4		
Aver.	4		0.2—	6.4	6.6	
Net N. E.	(Lime, manure and Georgia soil No. 1)					29.9
6392	5	240	0.2—	80.6		
6393	5	240	0.2—	83.7		
Aver.	5		0.2—	82.2	82.4	
6394	5	0	0.2—	64.3		
6395	5	0	0.2—	63.1		
Aver.	5		0.2—	63.7	63.9	
Net N. E.	(Indoor plat)					18.5

*This indicates imperfect sampling.

TABLE X—Continued.

PART 3.—Mixtures standing 4 weeks.

Lab. No.	Plat No.	Mgs. N. as Am. S.	Percentage of Initial Added N. Recovered as:			N. E.
			NO_2	NO_3	NO_2 and NO_3	
6497	1	240	0 1—	*4.1		
6498	1	240	0.0	3.0—		
Aver.	1		0.1—	3.6—	3.7—	
6499	1	0	0.0	3.0—		
6500	1	0	Not rec'd.			
Aver.	1		0.0	3.0—	3.0	
Net N. E.	(Lime)					0.7—
6501	2	240	0.1—	18.8		
6502	2	240	0.1—	23.8		
Aver.	2		0.1—	20.8	20.8	
6503	2	0	0.0	3.0—		
6504	2	0	0.0	1.0—		
Aver.	2		0.0	2.0—	2.0—	
Net N. E.	(Lime and manure)					18.8
6505	3	240	0.1—	†13.2		
6506	3	240	0.1—	‡ 5.6		
Aver.	3		0.1—	9.4	9.4	
6507	3	0	0.0	1.0—		
6508	3	0	0.0	1.0—		
Aver.	3		0.0	1.0—	1.0—	
Net N. E.	(Lime, manure and Georgia soil No. 1)					8.4
6509	4	240	0.1—	38.5		
6510	4	240	0.1—	32.2		
Aver.	4		0.1—	35.9	35.9	
6511	4	0	0.0	3.0—		
6512	4	0	0.0	3.0—		
Aver.	4		0.0	3.0—	3.0—	
Net N. E.	(Lime, manure and Georgia soil No. 1)					32.9
6513	5	240	0.3	95.2		
6514	5	240	0.3	105.2		
Aver.	5		0.3	100.2	100.5	
6515	5	0	0.1—	90.2		
6516	5	0	0.1—	88.9		
Aver.	5		0.1—	89.6	89.7	
Net N. E.	(Indoor plat)					10.8

Duplicates *14.7 discarded.
Duplicates †11.6 discarded.
Duplicates ‡ 9.4 discarded.

TABLE X—Continued.

PART 4.—Mixtures standing 8 weeks.

Lab. No.	Plat No.	Mgs. N. as Am. S.	Percentage of Initial Added N. Recovered as:			N. E.
			NO_2	NO_3	NO_2 and NO_3	
6691	1	240	0.1—	19.4	21.0	
6692	1	240	0.1—	21.3	----------	
Aver.	1		0.1—	20.9	----------	
6693	1	0	0.1—	3.0—	----------	
6694	1	0	0.1—	3.0—	----------	
Aver.	1		0.1—	3.0—	3.1—	
Net N. E.	(Lime)	----------	----------	----------	----------	17.9—
6695	2	240	0.1—	35.1	----------	
6696	2	240	0.1—	32.0	----------	
Aver.	2		0.1—	33.6	33.6	
6697(*a*)	2	0	0.0	18.5	----------	
6698(*b*)	2	0	0.1—	1.0—	----------	
Aver.	2		0.1—	9.8	9.9	
Net N. E.	(Lime and manure)		----------	----------	----------	23.7
6699	3	240	0.1—	24.4	----------	
6700	3	240	0.1—	28.8	----------	
Aver.	3		0.1—	26.6	26.6	
6701	3	0	0.1—	3.0—	----------	
6702	3	0	0.1—	3.0—	----------	
Aver.	3		0.1—	3.0—	3.1—	
Net N. E.	(Lime, manure and Georgia soil No. 1)			----------	----------	23.5+
6703	4	240	0.1—	24.7	----------	
6704	4	240	0.0	26.9	----------	
Aver.	4		0.1—	25.8	25.8	
6705	4	0	0.1—	3.0	----------	
6706	4	0	0.1—	1.0—	----------	
Aver.	4		0.1—	2.0—	2.1—	
Net N. E.	(Lime, manure and Georgia soil No. 1)			----------	----------	23.7+
6707	5	240	0.1—	99.0	----------	
6708	5	240	0.1—	95.5	----------	
Aver.	5		0.1—	97.3	97.3	
6709	5	0	0.1—	79.6	----------	
6710	5	0	0.1—	81.1	----------	
Aver.	5		0.1—	80.4	80.4—	
Net N. E.	(Indoor plat)	----------	----------	----------	----------	16.9+

6697(*a*).—Duplicate 19.7.
6698(*b*).—Duplicate by Tiemann-Schulze 1.0—.

TABLE X—Continued.

PART 5.—Mixtures standing 12 weeks.

Lab. No.	Plat No.	Mgs. N. as Am. S.	Percentage of Initial Added N. Recovered as:			N. E.
			NO_2	NO_3	NO_2 and NO_3	
6819	1	240	0.1	17.5		
6820	1	240	0.1—	22.5		
Aver.	1		0.1—	20.0	20.1	
6821	1	0		3.0—		
6822	1	0		3.0—		
Aver.	1			3.0—	3.0—	
Net N. E.	(Lime)					17.1+
6823	2	240	0.1—	45.7		
6824	2	240	0.1—	48.9		
Aver.	2		0.1—	47.3	47.4	
6825	2	0	0.0	15.0		
6826	2	0	0.0	15.7		
Aver.	2		0.0	15.4	15.4	
Net N. E.	(Lime and manure)					32.0—
6827	3	240	0.0	25.7		
6828	3	240	0.0	27.7		
Aver.	3		0.0	26.7	26.7	
6829	3	0		3.0—		
6830	3	0		3.0—		
Aver.	3			3.0—	3.0—	
Net N. E.	(Lime, manure and Georgia soil No. 1)					23.7+
6809	4	240	0.0	37.0		
6810	4	240	0.0	34.5		
Aver.	4		0.0	35.8	35.8	
6807	4	0	0.1—	3.0—		
6808	4	0	0.4	3.0—		
Aver.	4		0.3—	3.0—	3.3—	
Net N. E.	(Lime, manure and Georgia soil No. 1)					32.5+
6831	5	240	0.0	99.0		
6832	5	240	0.0	104.9		
Aver.	5		0.0	102.0	102.0	
6833	5	0	0.0	70.8		
6834	5	0	0.0	72.0		
Aver.	5		0.0	71.4	71.4	
Net N. E.	(Indoor plat)					30.6

The results are summarized in Table XI.

TABLE XI.—EXPERIMENT 357. Summary of table X showing the effect on N. E. of the addition of various substances.

Nitrification—summary of Table X.

Date.		Plat 1. Lime Added.		Plat 2. Lime and Cow Manure Added.		Plat 3. Lime, Cow Manure and Georgia Soil No. 1, 300 Lbs. Per Acre.		Plat 4. Lime, Cow Manure and Georgia Soil No. 1, 5 T. Per Acre.		Plat 5. Indoors, Lime, Cow Manure and Georgia Soil No. 1.	
Dec. 20, 1909	Total	1.2—		1.2—		1.2—		1.2—		1.2—	
	Control	1.2—		0.0		1.2—		1.2—		0.0	
	Net N. E.	-------	0.0	-------	1.2	-------	0.0	-------	0.0	-------	1.2
Jan. 3, 1910	Total	16.9		15.4		11.9		36.5		82.4	
	Control	3.2		3.2		18.2*		6.6		63.9	
	Net N. E.	-------	13.7	-------	12.2	-------	—6.3*	-------	29.9	-------	18.5
Feb. 14, 1910	Total	3.7—		20.8		9.4		35.9		100.5	
	Control	3.0		2.0		1.0		3.0		89.7	
	Net N. E.	-------	0.7	-------	18.8	-------	8.4	-------	32.9	-------	10.8
March, 14 1910	Total	21.0		33.6		26.6		25.8		97.3	
	Control	3.1—		9.9		3.1—		2.1—		80.4—	
	Net N. E.	-------	17.9+	-------	23.7	-------	23.5+	-------	23.7+	-------	16.9+
April 14, 1910	Total	20.1		47.4—		26.7		35.8		102.0	
	Control	3.0—		15.4		3.0—		3.3—		71.4	
	Net N. E.	-------	17.1+	-------	32.0—	-------	23.7+	-------	32.5+	-------	30.6

*Imperfect mixing.

All controls in Plats 1, 2, 3, and 4 agree in the main except the two weeks control in Plat 3 and the twelve weeks control in Plat 2. These exceptions are probably due to imperfect sampling leading to an excess of cow manure in the sample.

The controls in Plat 5 show the effect of the addition of large amounts of cow manure. They also show that the nitrates increase in this plat until the end of the first month and then gradually decrease. Even in this period 62.7 represents the nitrification of the first two weeks, and 25.8 the additional nitrification of the second two weeks.

Regarded from the amount of total nitrates present with the exception of two weeks Plats 2 and 3, the series with cow manure present, showed greater nitrification than when it was not present—usually much greater.

The addition to the lime manure plats of Georgia soil No. 1, in quantities corresponding to 300 pounds per acre, did not appreciably increase nitrification—indeed it lowered it and in some cases appreciably so. When added at the rate of five tons to the acre there was a marked increase in two cases and a decrease in two cases, leaving a doubt as to whether its effect in this amount was helpful or harmful.

REPORT OF WORK UNDERTAKEN AND ACCOMPLISHED

From About June 20, 1910, to November, 1911, on

Corn-bill Bug. *Sphenophorus Callosus.*

BY

R. I. Smith.

A biological study of *Sphenophorus callosus* and other injurious species of *Sphenophorus* occurring in North Carolina, was undertaken as an Adams Fund Project after being submitted for approval August 27, 1910, before which date a little preliminary study of the conditions had been made in Robeson and Columbus counties. This report covers all work that the writer has undertaken, most of which is complete so far as one year's work would admit.

A preliminary report to July 1, 1911, was furnished for the thirty-fourtth annual report of the Station. That report was written while the life history studies of the bill-bug were in progress, so that considerable work done during May and June could not be recorded except in a very general manner. Now, with the season's work brought to a close a full report for the season of 1911, since the bill-bugs first became active, is given in detail form.

The report shows that during the past spring, summer and fall, a complete life history record of the bill-bug has been secured. A close study of the different stages of the insects themselves has not been made, owing to the large amount of time required to follow the breeding work and securing such field observations as were necessary to prove that the results secured by breeding bill-bugs in confinement were practically comparable with field conditions.

PRELIMINARY INVESTIGATION AND REASONS FOR UNDERTAKING THIS PROJECT.

During the spring of 1910, corn bill-bugs were reported as doing unusual damage in Camden and other coastal counties. At the suggestion of Director C. B. Williams the writer prepared to investigate the conditions in view of undertaking this work.

A field trip to Columbus and Robeson counties was made by the writer on June 20, 1910. The first serious bill-bug injury discovered was at Braswell, Columbus County, on the farm of F. T. Shepherd. On June 21 a corn field was visited in which the third planting of corn was being destroyed by the bill-bugs. Previous to that date the owner had collected several hundred by hand, so that only small numbers could be found on June 21. Still the injury was quite severe and the third planting was practically a failure. During this trip bill-bug injury was discovered, and specimens collected at three points in Robeson County, namely, Lumberton, Proctorville, and Elrod, where in every case the bill-bugs were laying eggs and breeding in young corn plants, a condition not previously known to exist in this State. A rice field near Chadbourn was also found in which bill-bugs were breeding in large numbers.

The specimens of adult beetles collected on this trip were taken to the laboratory at West Raleigh and kept alive on green cornstalks in which they continued to lay eggs until September 3, and probably later, but after that date they were not given much attention. During the winter until February 14 the bill-bugs were buried in soil in a large tin can kept out of doors under shelter. Occasionally on warm days one or more beetles was seen moving about on the surface. This lot consisted of seventeen on September 3, when they were left to go into winter quarters. On February 14, 1911, they were dug out and sixteen found alive. On March 1 all were dead, probably because of being disturbed during the cool weather.

The above statements represent the first work with bill-bugs, and indicate, for one thing, that the beetles have a remarkable power of living a long time under adverse conditions, a fact which has been amply demonstrated during 1911.

During July and August, 1910, bill-bugs were found breeding in the stems and roots of Elegant Nutgrass, *Cyperus flavicomus,* in several fields on the College farm at West Raleigh. During August and September many larvæ, pupæ, and adults were collected from *C. flavicomus* growing in a corn field situated in low ground on the College farm. These specimens, that is the adults, were kept in an out-door cage during the winter, where they remained buried most of the time, and some of them commenced egg-laying about May 28, 1911, and lived until the latter part of October, when they were killed because no further use could be made of them.

LIFE HISTORY AND HABITS OF SPHENOPHORUS CALLOSSUS.

First Appearance of Beetles in Spring.

The adult bill-bugs appear in the eastern counties, in what is considered the bill-bug section of North Carolina, as soon as the earliest corn is sprouting. The date varies with different seasons. Injury commences at once and continues as long as young corn plants are available as food for the beetles. On May 9, 1911, at St. Pauls, Robeson County, the bill-bugs were killing the second planting of corn in a field on Marcus Smith's place, and Mr. Smith said the beetles had been observed in injurious numbers for over two weeks. It was from this place that most of the bill-bugs for breeding work were secured. The records show that bill-bugs did not lay eggs this spring (1911) until May 20 or 21.

Eggs.

The first eggs secured this year were on May 22, from a lot of over-wintered beetles collected at Braswell and Pembroke during October, 1910. It is possible that eggs were first laid on May 21, as that was Sunday and the material was not examined. On May 22 eggs were also discovered in Cyperus plants near West Raleigh. On May 26 Mr. Smith of St. Pauls wrote, "beetles have commenced to lay eggs in the corn plants," and as Mr. Smith had, by special arrangement, been looking daily for the eggs, this record may be taken as indicating about the date of first egg-laying in the field. As further evidence, a letter from

F. T. Shepherd of Braswell, dated May 17, states that, "bill-bugs have not commenced to lay eggs." Mr. Shepherd was also watching for earliest egg-laying in the field, at the writer's request. After May 22 the bill-bugs in confinement and in the field laid eggs quite regularly, as shown in the following egg-laying record.

Where, When, and How Eggs Are Deposited.

The eggs are placed by the female in specially prepared cavities in the stem of the food plant, usually within one or two inches of the ground, or sometimes just at the roots of the plants.

The female usually eats out a cavity in the thickened side of the outer corn blade and often consumes fifteen or twenty minutes in preparing this cavity. The narrow beak acts as a wedge to pierce the outer tissue, which practically closes when the beak is withdrawn. She then thrusts her ovipositer into the hole and places an egg entirely out of sight. The tissue of the leaf is forced apart by the ovipositer and the opening closes again almost completely when it is withdrawn. In very young corn plants the egg is placed in the same manner in the soft stem just above the roots. In larger corn the egg is imbedded in the outer blade and often can not be seen from either the inner or outer side. In Cyperus plants with thinner blades the eggs are usually found just underneath the outside blade and often two or three inches above ground.

After placing an egg the female always spends a few minutes scraping the tissue above the egg-cavity with her sharp ovipositer, evidently endeavoring to completely close up the opening.

While securing the daily egg-laying record several broken eggs were found, but the reason for it was not discovered. It is possible that the males may attempt to eat the eggs or possible that some are crushed while being deposited.

Eggs are evidently deposited in all plants on which the beetles feed. Eggs have been found in all the food plants listed on another page.

Number of Eggs Laid by Females.

The individual record of twenty-four females, in the following table, gives complete data of egg laying for the entire season of 1911. Most of the beetles secured for this record were collected at St. Pauls by Mr. Marcus Smith on May 25, and received on May 26, and were isolated as soon as mated pairs could be secured. The record, therefore, was commenced, except Nos. 1, 16, 18 and 24, about six days after the first eggs were discovered in the field. For this reason the record may lack five or six days' egg-laying, but with that exception it is complete.

Each pair was kept in a half pint jelly glass and given fresh food at least once a day, except when the record indicates that the eggs for two, or sometimes three days, were counted at one time. This was caused by the necessary absence of the writer, who took the notes for the entire record as shown in the table.

The pairs were kept in a wire cage under as near normal conditions as possible. The jelly glasses contained no earth because its presence would have interfered with securing every egg. On many occasions one or more eggs were found loose in the glass, even though the food supplied was in fresh condition. No doubt loose eggs are deposited occasionally around plants in the field.

Food was supplied in the form of a short section of corn plant usually cut from within an inch or two of the roots. During June and July young corn plants entirely suitable for food were easily secured from the field, but after the middle of August it became necessary to find suckers or search for small plants. In fact the food supplied was no better at any time than the beetles could have found in the corn fields. During September it was difficult to find any corn suitable for food and the beetles were forced to lay eggs in hard corn stalks, or in portions of the green stalk of late suckers.

The daily record was generally taken between 12 m. and 2 p. m. On a few days a record was taken about 7 a. m. and after 6 p. m., but these special records do not appear in the table.

The great difference in the number of eggs laid by different females may indicate that they were not under suitable conditions, but all had the same treatment and some which laid only a few eggs lived until after the record was discontinued, and many are probably still alive in a wire cage where all the live ones were placed on October 27.

All the females whose egg record was secured were alive on October 27, except where the record states that individuals died on certain dates.

SPHENOPHORUS CALLOSUS.

Daily Egg-laying record of twenty-four females.

1911	Pair No.																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
May 24	---	4	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
25	---	1	---	--	---	---	---	---	---	--	---	---	--	---	---	1	--	---	---	--	---	---	---	--
26	---	1	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	1	---	--	---	---	---	1
27	---	1	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	1	---	--	---	---	---	--
28	3	3	---	5	---	2	5	5	1	1	5	5	4	2	---	1	4	---	5	2	4	1	4	--
29	2	---	4	1	5	4	2	3	1	4	2	1	--	3	---	1	3	1	2	1	2	3	2	1
30	2	2	---	1	1	1	3	2	---	1	---	4	2	1	---	--	4	6	2	--	---	---	1	2
31	4	3	1	3	4	4	‡4	3	2	1	---	3	--	2	9	2	4	---	3	2	7	3	3	--
June 1	3	3	3	2	5	3	4	3	---	1	1	4	3	2	4	1	4	2	4	2	3	1	2	1
2	4	4	3	4	7	3	4	4	1	1	4	4	1	3	3	2	2	6	3	2	9	2	4	3
3	4	4	1	--	3	4	3	2	3	3	3	5	2	1	3	--	3	2	3	1	4	1	1	1
4	1	4	4	3	6	6	3	5	---	3	4	3	2	---	1	1	2	2	2	2	4	3	3	1
5	1	---	2	--	4	4	1	3	2	1	2	6	1	1	4	1	5	1	1	--	1	3	5	--
6	3	5	5	--	6	3	3	1	---	4	7	5	3	2	5	1	2	5	4	--	8	2	1	1
7	2	3	1	1	6	5	*4	3	1	3	4	3	1	2	2	4	2	1	---	1	4	2	1	--
8	1	3	2	--	3	4	1	2	---	--	4	5	--	---	2	1	1	3	3	2	4	---	3	--
9	2	2	---	--	4	4	2	3	---	3	3	3	--	2	4	1	1	---	---	--	4	2	1	--
10	1	3	3	--	3	3	1	---	2	4	3	6	2	2	4	1	--	5	3	1	6	3	1	--
11	2	2	1	1	4	3	3	3	---	2	2	4	--	1	2	--	1	1	1	--	1	3	3	--
Total	35	48	30	21	61	53	43	42	13	32	44	61	21	24	43	18	38	37	36	16	61	29	35	11

*One broken egg included. †Two broken eggs included. ‡Three broken eggs included.

SPHENOPHORUS CALLOSUS—Continued.

Daily Egg-laying record of twenty-four females.

1911	Pair No.																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
June 12	4	3	3	1	9	*3	*2	2	2	†5	5	6	2	5	6	1	2	3	2	2	3	*3	*1	1
13	3	3	---	1	3	1	1	2	2	2	5	3	1	3	5	1	2	3	3	1	1	3	2	1
14	3	4	3	3	6	---	1	1	1	--	3	7	--	---	6	4	1	2	1	1	6	*4	3	--
15	2	3	3	--	4	5	4	1	---	2	4	2	1	1	4	1	--	2	1	--	1	2	3	--
16	1	4	4	2	7	6	---	2	1	*4	5	8	1	6	8	2	2	3	---	2	4	4	2	--
17	4	1	*2	2	3	2	5	2	1	4	2	7	--	2	7	--	1	5	---	--	5	3	3	--
18	2	3	2	--	4	4	1	2	1	1	6	1	--	---	*2	1	1	2	---	--	2	1	---	--
19	4	2	4	3	4	6	*4	3	3	4	4	4	--	4	*7	--	1	5	---	--	3	3	2	1
20	2	3	2	--	5	*5	---	2	2	3	5	4	--	2	6	2	--	2	1	1	4	---	3	1
21	2	2	3	2	6	*5	3	2	3	4	4	5	1	1	4	--	2	3	---	2	4	6	1	--
22	2	4	*2	1	5	*3	1	2	2	2	2	4	2	3	†5	--	--	*4	1	--	*3	2	3	--
23	2	5	3	2	*3	4	3	1	3	4	5	8	2	1	*5	--	2	4	---	--	*2	5	---	--
24	3	3	4	2	*5	7	2	4	3	4	5	1	3	1	10	--	1	4	---	--	1	*4	4	--
25	3	4	*3	1	8	3	2	3	1	2	*4	†6	1	*3	5	--	4	2	---	--	3	2	---	--
26	4	4	4	2	*6	7	2	3	2	3	*6	†5	2	*4	9	--	3	5	---	--	3	4	1	--
27	4	5	3	--	3	*8	1	1	---	1	6	9	1	3	7	--	--	5	---	--	1	2	---	--
28	2	6	3	3	*6	5	---	4	3	1	*3	4	1	1	5	--	*3	2	---	--	2	3	---	1
29	3	6	†5	--	4	4	---	3	2	--	6	6	--	3	7	--	--	2	---	--	2	2	---	--
30	2	4	*5	1	2	†6	2	*2	3	--	*5	*2	1	1	6	--	2	4	2	--	4	4	---	--
July 1	2	4	6	2	4	5	---	2	2	--	2	4	1	3	†6	--	--	†3	---	--	4	5	1	1
2	---	5	3	1	2	7	---	*2	4	--	3	*11	--	2	5	--	--	*3	---	--	2	4	2	--
3	1	5	6	--	3	5	2	1	2	--	6	5	--	3	4	--	1	2	---	--	3	4	2	--
4	1	*4	4	--	4	5	---	5	2	--	4	4	1	2	4	--	--	1	---	1	1	1	---	--
5	---	*3	*2	1	4	*3	1	4	2	--	*4	6	--	2	7	--	--	2	---	--	4	5	1	--
6	---	6	*4	1	4	5	---	3	4	--	4	4	--	*5	5	--	1	1	1	--	3	*3	2	--
7	1	3	2	--	*3	*3	1	3	1	--	*7	8	--	4	---	--	--	---	---	--	3	4	1	--
8	1	*7	*3	--	5	2	---	5	3	--	3	*5	--	*4	4	D	--	*2	---	--	2	*8	---	--
9	2	5	3	--	4	5	---	2	3	--	5	5	--	4	2	--	--	1	---	--	3	4	3	2
10	3	4	†3	--	3	3	2	4	3	--	4	4	--	3	6	--	1	1	---	--	2	3	---	--
Total	63	115	94	31	129	127	40	73	61	46	127	148	21	76	157	12	30	78	12	10	81	98	40	8
July 11	1	6	3	--	1	8	---	*2	1	--	3	4	--	5	3	--	--	---	3	--	5	6	2	--
12	---	5	4	--	4	5	1	4	3	--	4	9	--	5	7	--	--	---	*4	1	3	*3	---	--
13	2	6	1	--	5	1	1	4	3	--	4	9	--	3	6	--	--	1	*4	--	1	1	1	--
14	*3	5	2	--	4	5	---	*2	3	--	4	4	--	4	6	--	--	---	5	--	2	5	1	1
15	*3	3	2	--	2	3	---	2	2	--	5	5	--	4	3	--	--	---	5	--	2	5	2	--
16	---	5	*3	--	4	†5	1	†4	5	--	3	*7	--	3	3	--	--	---	6	--	*3	*5	2	--
17	---	5	3	--	6	†4	---	3	3	--	6	6	--	2	*3	--	2	1	4	--	*3	4	1	1
18	1	7	*4	--	3	*3	---	6	4	--	4	6	1	3	8	--	1	---	5	--	4	3	1	2
19	1	5	†6	--	3	4	1	4	3	--	3	*5	--	4	*3	--	--	---	6	--	3	4	3	--
20	---	2	†7	--	2	7	---	4	3	--	1	3	--	2	*4	--	--	---	4	--	2	*3	*2	2
21	1	7	†5	1	5	5	1	3	5	--	*5	*8	--	*5	4	--	--	---	*4	--	3	*7	1	1
22	---	4	8	--	2	†7	2	2	4	--	6	2	--	4	1	--	1	1	*5	--	3	*4	1	1
23	---	3	4	--	5	*4	1	3	4	--	4	†5	--	3	3	--	--	---	‡5	--	2	7	1	1
24	1	6	5	--	3	2	1	*5	5	--	6	4	--	5	1	--	--	---	4	--	2	5	1	--
25	1	7	10	--	5	*10	2	2	5	--	4	7	--	5	5	--	--	1	*6	--	2	6	1	--
26	---	1	3	--	1	3	1	1	3	--	5	2	--	2	---	--	--	---	*1	--	4	1	1	1
27—28	1	7	‡9	--	5	*6	2	5	6	--	9	*6	--	8	5	--	1	1	3	--	*3	*7	2	1
29	---	7	*7	--	4	5	2	2	3	--	5	1	--	2	6	--	--	1	1	--	3	3	2	--

*One broken egg included. †Two broken eggs included. ‡Three broken eggs included. D.—Died.

SPHENOPHORUS CALLOSUS—Continued.

Daily Egg-laying record of twenty-four females.

1911	Pair No.																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
July 30	1	6	3	--	3	7	3	3	5	--	5	6	1	3	--	--	--	--	*2	--	4	*4	--	2
31	1	3	4	--	3	2	3	3	3	--	*3	3	--	5	2	--	--	--	2	--	*2	*4	4	--
August 1	1	8	6	--	6	8	1	--	5	--	6	2	--	1	4	--	--	--	2	--	5	3	1	--
2	1	3	2	--	3	4	2	2	2	--	3	3	1	5	--	--	--	--	1	--	3	3	3	1
3	1	5	*4	--	3	1	--	2	4	--	7	--	1	4	--	--	--	--	3	--	5	8	4	--
4	1	5	7	--	4	*5	1	--	4	--	6	--	--	2	2	--	--	--	3	--	2	3	3	--
5	--	6	3	--	3	4	1	2	2	--	4	--	2	--	2	--	--	--	4	--	4	6	2	1
6	2	4	7	--	5	4	1	--	6	--	6	--	--	--	2	--	--	--	3	--	*4	4	3	--
7	--	4	7	--	4	*4	--	--	2	--	8	--	--	5	7	--	--	--	4	--	4	4	3	--
8—9—10	--	*11	9	--	*5	‡10	--	--	*11	--	12	2	4	--	--	--	--	--	3	--	*7	10	4	--
11	--	4	*6	--	*1	4	--	--	3	--	6	--	1	4	1	--	--	--	*4	--	4	3	--	--
12	--	5	6	--	1	4	--	--	2	--	4	--	2	--	--	--	--	--	1	--	3	4	4	--
Total	23	155	150	1	105	144	28	70	114	0	151	108	13	98	91	0	5	6	107	1	97	135	56	15
Aug. 13—14—15	--	*13	8	--	5	*11	--	--	4	--	10	2	2	6	--	--	--	--	1	--	6	11	4	1
16	--	5	2	--	--	--	--	--	*4	--	2	D	--	--	--	--	--	--	4	--	*4	5	1	--
17	--	2	1	--	--	2	--	--	1	--	--	--	1	--	1	--	--	--	--	--	2	3	1	--
18	--	8	3	--	1	3	--	--	5	--	3	--	2	--	D	--	--	--	--	--	1	4	*3	--
19	--	3	*3	--	4	6	--	--	4	--	4	--	1	1	--	--	--	--	3	--	6	7	2	--
20	--	5	3	--	1	3	--	--	3	--	4	--	--	1	--	--	--	--	1	--	5	3	2	--
21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
22	--	10	2	--	4	*6	--	--	5	--	5	--	2	3	--	--	--	--	--	--	*4	*6	*6	3
23	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	4	4	--	1	4	--	--	1	--	5	--	--	--	--	--	--	--	2	--	*3	3	3	--
25—26	--	*5	--	--	--	7	--	--	1	--	*7	--	1	3	--	--	--	--	--	--	*4	*3	2	--
27	--	4	--	--	2	2	--	--	*3	--	6	--	--	--	--	--	--	--	--	--	4	3	4	--
28	--	4	--	--	1	*2	--	--	4	--	2	--	--	--	--	--	--	--	--	--	1	†3	5	1
29	--	4	--	--	1	5	--	--	4	--	6	--	--	--	--	--	--	--	--	--	*4	1	3	--
30	--	5	--	--	2	5	--	--	3	--	2	--	--	--	--	--	--	--	--	--	*2	5	2	--
31	--	5	--	--	--	4	--	--	3	--	1	--	1	--	--	--	--	--	--	--	3	3	2	--
September 1—2	--	7	1	--	4	5	--	--	5	--	6	--	--	--	--	--	--	--	--	--	2	3	5	--
3—4	--	7	7	--	3	4	--	--	6	--	6	--	--	--	--	--	--	--	--	--	3	*6	*5	--
5	--	2	2	--	--	1	--	--	1	--	3	--	--	--	--	--	--	--	--	--	--	--	1	--
6	--	5	--	--	--	5	--	--	2	--	--	--	--	--	--	--	--	--	--	--	1	1	1	--
7	--	2	--	--	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--
8	--	3	--	--	--	1	--	--	2	--	--	--	--	--	--	--	--	--	--	--	1	2	--	--
9	--	*5	--	--	--	1	--	--	1	--	4	--	--	--	--	--	--	--	--	--	--	2	2	--
10—11	--	*7	--	--	1	3	--	--	1	--	2	--	--	--	--	--	--	--	--	--	--	2	*4	--
12	--	4	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	2	2	--
13	--	1	--	--	1	--	--	--	--	--	4	--	--	--	--	--	--	--	--	--	--	--	2	--
14	--	--	--	--	--	1	--	--	--	--	1	--	--	--	--	--	--	--	K	--	--	--	--	--
15	--	1	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
16	--	2	3	--	1	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--
Total	0	123	39	0	32	84	0	0	67	0	85	2	10	14	1	0	0	0	11	0	56	81	63	5

*1 broken egg included. †2 broken eggs included. ‡3 broken eggs included.
D.—died. K.—killed.

SPHENOPHORUS CALLOSUS—Continued.

Daily Egg-laying record of twenty-four females.

1911 Date.	Pair No.																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
September 17	---	---	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
18	---	3	---	--	---	1	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	1	--
19	---	1	---	--	---	1	---	---	---	--	1	---	--	---	---	--	--	---	---	--	---	---	1	--
20	---	1	---	--	1	1	---	---	1	--	1	---	--	---	---	--	--	---	---	--	---	---	---	--
21	---	---	---	--	D	---	---	---	---	--	---	---	--	---	---	--	--	---	---	--	1	---	---	--
22	---	---	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
23	---	---	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
24	---	---	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
25	---	---	---	--	---	---	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
26—27	---	1	1	--	---	1	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
28—29	---	---	---	--	---	1	---	---	---	--	---	---	--	---	---	--	--	---	---	--	---	---	---	--
Total	0	6	1	0	1	5	0	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	2	0
From 1st page	35	48	30	21	61	53	43	42	13	32	44	61	21	24	43	18	38	37	36	16	61	29	35	11
From 2d page	63	115	94	31	129	127	40	73	61	46	127	148	21	76	157	12	30	78	12	10	81	98	40	8
From 3d page	23	155	150	1	105	144	28	70	114	--	151	108	13	98	91	--	5	6	107	1	97	135	56	15
From 4th page	---	123	39	--	32	84	---	---	67	--	85	2	10	14	1	--	--	---	11	--	56	81	63	5
Grand total	121	447	314	53	328	413	111	185	256	78	409	319	65	212	292	30	73	121	166	27	296	343	196	39

Total number laid by 24 females, 4,894 eggs.
Average number laid by each female, 204 eggs.

Egg Laying Record for Each Month. Condensed From Above Table.

1911	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
May 24—31	11	15	5	10	10	11	14	13	4	7	7	13	6	8	9	5	15	9	12	5	13	7	10	4
June	76	102	83	37	144	126	63	71	44	71	122	140	34	60	148	25	50	90	35	20	102	79	53	12
July	28	146	129	6	106	139	28	95	92	--	131	157	4	109	116	--	8	22	80	2	83	128	39	16
August	6	132	83	--	57	108	6	6	93	--	119	9	21	35	19	--	--	---	39	--	90	108	69	7
To September 29	---	52	14	--	11	29	---	---	23	--	30	---	--	---	---	--	--	---	---	--	8	21	25	2
Totals for 5 months	121	447	314	53	328	413	111	185	256	78	409	319	65	212	292	30	73	121	166	27	296	343	196	39

Summarized Notes From the Above Egg Laying Record.

Average number of eggs from each female—204.

Longest egg-laying period, No. 2, May 24 to September 27.

Shortest egg-laying period for beetle that lived all the season after ceasing to lay eggs, No. 10, May 28 to June 28.

Female No. 20, which laid only 27 eggs in all, was apparantly healthy and fed normally after ceasing to lay eggs.

Female No. 24, which laid only 39 eggs, but laid occasionally for a period of three months, was also apparently in a healthy condition at the end of the season.

Female No. 2, which laid the highest total, did not miss laying every day except May 29, and June 5,—and on the latter date it was accidentally left without food—from May 24 to September 14, showing a remarkable regularity.

Eleven eggs is the highest record for any twenty-four hour period. Where a larger number of eggs is recorded it will be observed that the record covers two days in one counting.

Maximum egg-laying period was practically four months, and using that time as a basis, the average daily egg deposition would be less than two per day.

A careful study of the egg-laying record would not in every respect indicate the normal egg-laying habit of the bill-bug. However, considering the conditions under which the record was secured, the writer feels that it gives a very fair and normal record. It is reasonable to suppose that the egg-laying capacity of the beetles under average field conditions must vary as greatly as does this record.

Egg Laying of Females That Laid Only a Few Eggs or None at All.

When females for the season's egg record,—as recorded in above table—were secured, several other pairs were also taken and kept for one or more months. These additional records are of value in showing that bill-bugs do not all lay eggs under laboratory conditions, and future investigation may prove that the same thing is true of beetles in the field.

The numbers given these pairs commence, for convenience in recording, at twenty-five and run up to forty-nine, and show that forty-nine females were selected at the start for securing the full egg record.

The record of each female was as follows:

Record of 11 Adults That Laid Only a Few Eggs.

Female No.	Date of Laying First Eggs.	Date of Laying Last Egg.	Total number Eggs deposited.	Date of Discarding or Killing Female.	Remarks.
25	May 28	June 13	13	July 17	Feeding and apparently healthy July 17.
26	May 28	July 7	23	July 19	Feeding and apparently healthy July 19.
27	May 27	July 19	12	do.	Last 5 eggs from July 5 to 19.
28	May 26	July 19	21	do.	Last 4 eggs from July 13 to 19.
29	May 28	June 13	9	do.	Feeding and healthy on July 19.
30	May 31	June 10	10	do.	do.
31	June 1	July 3	12	do.	do.
32	May 28	June 14	24	do.	do.
33	May 24	May 27	4	do.	do.
34	May 29	June 5	8	do.	do.
35	June 3	July 3	8	do.	do.

The above record of females Nos. 25 to 35 is interesting because the beetles were kept under the same conditions as those that laid eggs for nearly four months. Some of these beetles were dissected on July 19, to see if any eggs were still in the body, but in no case were any found when the beetles had ceased to lay for over a month. Females Nos. 27 and 28 had fully developed eggs in the body, but for some reason they were laying a comparatively small number at the time of stopping their record.

Record of Fourteen Females That Laid No Eggs.

Fourteen pairs of beetles taken on May 27 or 28, at the same time and kept under exactly the same conditions as those recorded in the season's egg-record, failed to lay eggs at all. They were kept until July 5 and 7. For convenience these pairs were numbered 36 to forty-nine inclusive.

The females fed regularly and were apparently as healthy and vigorous as the ones that laid eggs. When the egg record was first commenced it was thought that these females might commence to lay eggs later than the usual time, and for that reason they were kept under daily observation and fed regularly with fresh cornstalks for food. Several of them were dissected between July 5 and 7 and found to have no eggs in the body.

Summary of Egg Laying Records.

Forty-nine mated females were taken between May 24 and 28.

Several proved to lay only a few eggs, or none at all and were not kept under observation after five or six weeks.

June 3 was the latest date on which any female commenced to lay eggs.

September 28-29 was the latest date for egg-laying this season.

No definite reason was discovered to show why some females did not lay any eggs, and—

No definite reason was discovered to show why some females laid so few eggs for a long period or stopped laying entirely after a few weeks.

447 eggs for female No. 2 was the maximum egg-laying record.

Over 400 eggs were laid by females Nos. 6 and 11.

Over 300 eggs were laid by females Nos. 3, 4, 12 and 22.

Over 200 eggs were laid by females Nos. 9, 14, 15 and 21.

Egg Hatching Records.

During the period from May 24 to August 2, 58 separate lots of eggs containing a total number of 364 and consisting of lots of from one to thirty, were hatched under varying degrees of temperature and moisture conditions. It was found that the eggs could be greatly retarded by a dry atmosphere, such as was obtained when the eggs were placed in glass vials plugged with cotton, with no extra moisture, while the hatching could be hastened by supplying moisture, either by adding drops of water or a piece of succulent cornstalk.

The eggs secured for the incubation records were those laid by the females kept for a daily egg-laying record. Most of these eggs were embedded in a corn stalk or in the outer leaf. Some were hatched in small glass vials loosely closed with cotton and some in small tin boxes, the latter perforated to admit air.

Many of the hatching records were not closer than twelve, or sometimes twenty-four hours, but they served as checks to prove that the close records were comparable with natural conditions.

All incubation records were secured in a wire covered house where temperature and moisture conditions were as near normal as possible.

In the following table is given a record of eggs of which the incubation period was secured to within less than twelve hours. Some of the records are almost exact. "Just hatching" means that the shell was cracked but the larva not free from the egg shell. "Just hatched" indicates that the larva had gotten free from the shell, but that the head of the larva had not had time to change color.

INCUBATION RECORD OF EGGS OF SPHENOPHORUS CALLOSUS.

Lot No.	Total No. of Eggs.	Date and Hour When Eggs Were Laid.	Date and Hour of Hatching.	Number of Hours Required for Hatching.		
				Min.	Max.	Aver.
3	2	May 23, 6 p. m. to 10 p. m.	May 30, 10 a. m. Just hatched.	156	160	158
5	1	May 23, 11 p. m. to May 24, 9 a. m.	May 31, 3 p. m. Just hatched.	174	184	179
6	1	May 24, 10 a. m. to 5 p. m.	June 1, 1:30 p. m. Just hatching.	188½	195½	192
10	1	May 26, 7 a. m. to 6 p. m.	June 2, 8 a. m. Just hatched.	158	169	163½
15	1	May 27, 10 a. m. to 4 p. m.	June 4, 10 a. m. Just hatching.	186	192	189
17	5	May 29, 12 m. to 4 p. m.	June 4, 11 a. m. Just hatched.	139	143	141
20	3	May 29, 12 m. to 2 p. m.	June 4, 8 p. m to June 5, 7 a. m.	150	162	156
21	1	May 29, 1 p. m. to 2 p. m.	June 4, 11 a. m. Just hatched.	141	142	141½
25	2	June 2, 1 p. m. to 3 p. m.	June 8, 7 p. m. Just hatched.	148	150	149
29	1	June 3, 4 p. m. to 6 p. m.	June 10, 12 m. Just hatched.	162	164	163
32	1	June 5, 4 p. m. to 6 p. m.	June 12, 9 a. m. Just hatched.	159	161	160
35	1	June 5, 4 p. m. to 6 p. m.	June 14, 12 m. to 4 p. m.	210	216	213
44	3	June 9, 8 p. m. to June 10, 6 a. m.	June 15, 6 p. m. Just hatching.	132	142	137
45	7	June 10, 8 a. m. to 6 p. m.	June 16, 3 p. m. Hatched and Hatching.	141	151	146
49	6	June 17, 10 a. m. to 5 p. m.	June 23, 10 a. m. Just hatched.	137	144	140½
51	5	July 25, 1 p. m. to 5 p. m.	July 31, 12 m. to 5 p. m.	139	148	140½
55	5	Aug. 1, 1 p. m. to 5 p. m.	Aug. 6, 11 p. m. Just hatched.	126	130	138

Summary of Incubation Record, With Additional Notes.

The average incubation period for the eggs recorded in above record is practically 159 hours or a little over six and a half days.

The shortest average period is 128 hours for five eggs deposited August 1, or practically five and one-third days. These eggs hatched in a tin box with plenty of moisture and during the warmest part of summer.

The longest average period of 213 hours, or practically nine days, was secured from an egg kept in a rather dry atmosphere and was in no way due to being retarded by cool weather.

Eggs were hatched in less than five days on two occasions. The first was a lot of thirteen eggs taken June 25, 1 p. m., and laid during the previous twenty-four hours or less. On June 29 at 1 p. m., one egg had hatched and the others hatched before night. Another lot of six eggs taken between June 26, 10 a. m. and 3 p. m., were hatching on July 1 at 9 a. m. All hatched at less than five days old.

Five days for egg-hatching should not, however, be considered as the average minimum time. During the progress of the breeding work hundreds of eggs were hatched for the purpose of securing larva for rearing and while records of all were not kept, it is safe to say that only a small per cent hatched in less than six days.

Eggs kept in a very dry atmosphere may be greatly retarded and very few will hatch unless moisture is furnished before the eggs are seven or eight days old. One lot of about 20 eggs taken June 26, 1 p. m., same being over twelve hours old, were kept very dry until July 5, when moisture was added. At that time no eggs had hatched and many were shriveled. On July 6 and 7 nine of the eggs hatched. Over 60 per cent failed to hatch. Such a condition is not liable to occur in the field, but the record proves that moisture is necessary for egg hatching.

Enemies of Eggs.

Ants have been discovered carrying *Sphenophorus* eggs into the ground. Just how much benefit they cause by destroying the eggs, the writer has not had a chance to discover. An egg dropped or placed on the ground, or exposed on the plants, is very quickly taken away by the little field ants. No other enemy of the egg has been discovered.

Larva.

The development of the larva during the warm summer months depends very largely upon its food supply. Hundreds of larvæ have been watched and a large number reared to maturity, as explained farther on, but normal development is retarded or entirely prevented by a poor food supply. Temperature conditions affect the growth of the larvæ after the latter part of August and especially so during September and October when some late hatching individuals undoubtedly occur in the field. These, however, are of minor importance since the majority of the brood must mature during August or September.

The observations and breeding work of the past season indicate clearly that the larvæ are normally present in corn and cyperus plants at all times during the summer after the first eggs hatch. A large number of these larvæ are hatched in plants too small to furnish them sufficient food for reaching mature growth. Hundreds of larvæ have been observed in cyperus plants that were too small, and the larvæ in them either died or found their way to other plants close by.

In the bill-bug sections of North Carolina which have been visited by the writer, the larvæ are readily found in all the plants on which the adults feed, namely, cyperus plants of several species, rice and corn. The writer has not found them in any of the common grasses, although other species of *Sphenophorus,* particularly the little *S. parvulus* are known to live in the roots of certain common grasses.

Method of Rearing Larvæ and Adult Beetles.

For rearing larvæ to maturity, corn stalks have been found more suitable than any other food plant. In the field the larvæ in corn plants are located near the roots, but in order to watch the development of the larvæ it was found necessary to force them to feed in the main stalk just above the roots. In all the rearing experiments recorded in these pages larvæ were placed in sections of corn stalk which were in some instances kept on moist soil, and in others, kept on top of dry soil. The latter method was found best in order to keep the larvæ from emerging and getting lost if the food did not exactly suit them.

Records of Larval Development.

The full records for the breeding experiments show that 81 specimens were reared from egg to adult stage. That is, larvæ were taken within a few hours, or within at most one day after hatching and were carefully placed in a cavity in the side of a green stalk at a point one or two inches above the root as the plant originally stood in the field. The surface of the piece of the stalk cut out to form the cavity, was always replaced and secured by a rubber band. In addition to the 81 larvæ reared to maturity, records were kept on the growth of 208 other larvae which were reared to the first, second, third or fourth molt, but failed to reach maturity either because of being killed or hurt during the times they were being examined, or because the corn stalk in which they were placed became unfit for food. In some instances the corn stalk got too dry and hard, while at other times it commenced to decay and the growth of black mould interfered with the normal growth of the larva. Some larvæ were also killed by mites, which at times interfered seriously with the experiments.

The larvæ that were reared to maturity were numbered from 1 to 81, these numbers being given after the completion of the work. It is possible that the development of some of the larvæ was retarded slightly by the almost daily examination which was necessary to determine just when the molts occurred. In the following table only the dates showing when the larvæ molted, are given, but the full records of the work show in some cases, that the larvæ were actually seen nearly every day.

The following table does not show, in every instance when the molts occurred, but the records given are very close, at least to within less than twenty-four hours, unless otherwise stated.

This table shows also the length of the pupal stage for those that emerged as mature beetles.

Nos. 1 to 63 were all reared to the mature beetle stage.

The records of Nos. 64 to 81 were not kept after the pupæ were secured.

RECORD OF DURATION OF LARVAL AND PUPAL STAGES.

Record No.	Date of Hatching.	Date of Shedding 1st Molt.	Date of Shedding 2d Molt.	Date of Shedding 3d Molt.	Date of Shedding 4th Molt.	Date of Pupating.	Date Adult Emerged.	No. of Days Laval Stage.	No. of Days Pupal Stage.	Sex of Beetle.
1	June 3, 4–7 p. m.	?	June 23–24	?	July 13, 10 a. m. Just molted	July 21, 6 p. m. July 22, 9 a. m.	July 30, 12 m.– July 31, 10 a. m.	48	9	Female
2	June 4, 10–11 a. m.	?	?	?	July 1, 10 a. m. Quite recent	July 8, 10 a. m.	July 17, 10 a. m.	34	9	Female
3	June 3, 6 p. m.– June 4, 9 a. m.	?	?	?	?	July 7, 5 p. m. July 8, 10 a. m.	July 16, 11 a. m.	34	8	Male
4	June 8 About 7 a. m.	June 12–13	June 25–26	July 5–6	July 11, 11 a. m. Quite recent	July 18, 7 p. m. July 19, 11 a. m.	July 28, 2–5 p. m.	40	9½	Female
5	June 8, 7 p. m.– June 9, 9 a. m.	?	?	?	July 3–4	July 13, 6 p. m. July 14, 9 a. m.	July 22, 10 a. m.– 4 p. m.	35	8½	Female
6	June 8 About 7 p. m.	June 12–13	June 19–20	?	July 1, 11 a. m. Just molted	July 10, 7 p. m. July 11, 9 a. m.	July 19, 11 a. m. July 20, 9 a. m.	32	9	Male
7	June 9, 10 a. m.–4 p. m.	?	?	?	?	July 8, 7 p. m. July 9, 10 a. m.	July 17, 1 p. m. July 18, 9 a. m.	29½	9	Male
8	June 9 10 a. m.–4 p. m.	June 15–16	?	?	July 1, 9 a. m.	July 6, 6 p. m. July 7, 9 a. m.	July 14, 11 a. m. July 15, 10 a. m.	27½	8	Female
9	June 9 12 m.–6 p. m.	June 14–15	June 19–20	June 23–24	June 30 July 1	July 5, 5 p. m. July 6, 11 a. m.	July 13, 12 m. July 14, 10 a. m.	26½	8	Male
10	June 10 At 11 a. m.	June 15 About 12 m.	?	July 10–11	July 15–16	July 24 10 a. m.–1 p. m.	Aug. 3, 9 a. m. Emerging	44	9	Female
11	June 9, 5–6 p. m.	June 14–15	?	June 23–24	July 2–3	July 12, 6 p. m. July 13, 9 a. m.	July 22, 4 p. m. Emerging	33	9½	Female
12	June 10, 11 a. m. June 11, 12 m.	June 14–15	June 23–24	June 27–28	July 5–6	July 15, 2 p. m. July 16, 11 a. m.	July 24, 9 a. m. Just adult	36	8½	Male
13	June 9, 6 p. m.– June 10, 6 a. m.	June 15–16	June 19–20	?	July 1, 10 a. m. Just molted	July 9, 7 p. m. July 10, 9 a. m.	July 18, 10 a. m. July 19, 11 a. m.	30	9	Female
14	June 10–11	?	?	?	July 2–3	July 10 10 a. m.–6 p. m	July 19, 11 a. m. July 20, 9 a. m.	30	9	Female
15	June 10, 7 p. m.– June 11, 9 a. m.	?	June 22, 10 a. m. Just molted	June 27–28	July 5–6	July 18, 7 p. m. July 19, 10 a. m.	July 27, 6. p. m. July 28, 9 a. m.	38	9	Male
16	June 13 9 a. m.–2 p. m.	June 19–20	June 27–28	July 2–3	July 10–11	July 18, 10 a. m. July 19, 10 a. m.	July 28, 9 a. m. Emerging	35½	9½	Male

Record of Duration of Larval and Pupal Stages—*Continued.*

Record No.	Date of Hatching.	Date of Shedding 1st Molt.	Date of Shedding 2d Molt.	Date of Shedding 3d Molt.	Date of Shedding 4th Molt.	Date of Pupating.	Date Adult Emerged.	No. of Days Larval Stage.	No. of Days Pupal Stage.	Sex of Beetle.
17	June 13 9 a. m.-2 p. m.	?	?	?	?	July 19, 6 p. m. July 20, 9 a. m.	July 29, 12 m. Emerging	$36\frac{1}{2}$	$9\frac{1}{2}$	Female
18	June 13, 4-6 p. m.	?	June 23-24	June 28-29	July 7-8	July 16, 12 m. July 17, 10 a. m.	July 26, 9 a. m. Emerging	33	$9\frac{1}{2}$	Male
19	June 15, 6 p. m.	June 19-20	June 25-26	July 2-3	July 5-6	July 15, 10 a. m.-1 p. m.	July 23, 6 p. m.- July 24, 9 a. m.	30	$8\frac{1}{2}$	Female
20	June 15, 10 a. m.	June 21-22	June 25-26	?	July 5-6	July 11, 10 a. m.- July 12, 9 a. m.	July 21, 10 a. m. Emerging	$26\frac{1}{2}$	$9\frac{1}{2}$	Female
21	June 15, 7 p. m.- June 16, 9 a. m.	June 21-22	June 25-26	July 2-3	?	July 11, 6 p. m.- July 12, 9 a. m.	July 20, 4 p. m.- July 21, 9 a. m.	28	9	Male
22	June 15, 7 p. m.- June 16, 9 a. m.	June 19-20	June 23-24	June 27-28	July 10-11	July 18, 9:30 a. m. Just pupated	July 26, 10 a. m.- July 27, 9 a. m.	$32\frac{1}{2}$	$8\frac{1}{2}$	Female
23	June 15, 6 p. m.- June 16, 9 a. m.	June 26-27	July 1	?	July 13, 9 a. m. Just molted	July 26, 1 p. m. Just pupated	Aug. 4, 7 p. m.- Aug. 5, 9 a. m.	$40\frac{1}{2}$	$9\frac{1}{2}$	Female
24	June 21, 6 p. m.- June 22, 9 a. m.	June 25-26	June 29-30	July 4-5	July 11, 12 a. m. Just molted	July 17, 4 p. m.- July 18, 9 a. m.	July 25, 6 p. m.- July 26, 10 a. m.	26	8	Female
25	June 21, 6 p. m.- June 22, 9 a. m.	?	July 4-5	?	July 26, 10 a. m. Just molted	Aug. 7, 2 p. m. Just pupated	Aug. 15, 6 p. m. Just emerged	47	$8\frac{1}{6}$	Female
26	June 21, 6 p. m.- June 22, 9 a. m.	June 28-29	?	?	July 11	July 22 10 a. m.-4 p. m.	July 31, 4 p. m. Just emerged	$30\frac{1}{2}$	9	Female
27	June 22 11 a. m.-3 p. m.	June 28-29	July 2-3	July 11-12	July 19-20	Aug. 3, 2 p. m. Just pupated	Aug. 12, 9 a. m. Emerging	42	$8\frac{3}{4}$	Female
28	June 22, 8-9 a. m.	June 26, 11 a. m. Just molted	June 29-30	?	?	July 28, 6 p. m.- July 29, 9 a. m.	Aug. 7, 9 a. m. Emerging	46	$8\frac{1}{2}$	Female
29	June 22 11 a. m.-3 p. m.	June 28-29	July 4-5	July 10-11	July 15-16	July 24, 6 p. m.- July 25, 9 a. m.	Aug. 4, 9 a. m. Quite recent	$32\frac{1}{2}$	10	Female
30	June 21-22	June 28-29	July 2-3	July 6-7	July 15-16	July 20, 6 p. m.- July 21, 9 a. m.	July 30, 11 a. m.- July 31, 9 a. m.	29	10	Female
31	June 21-22	June 27-28	July 2-3	July 6-7	July 16-17	July 25 10 a. m.-6 p. m.	Aug. 4, 3:30 p. m. Just emerging	$33\frac{1}{2}$	10	Female
32	June 22, 6 p. m.- June 23, 9 a. m.	June 26-27	July 1	July 5-6	?	July 22 11 a. m.-4 p. m.	July 31, 1 p. m. Just adult	$30\frac{1}{2}$	9	Female

33	June 23 11 a. m.-4 p. m.	June 28, 10 a. m. Just molted	July 2–3	July 5–6	July 18, 11 a. m.	July 28, 10 a. m.– July 29, 9 a. m.	Aug. 7, 9 a. m. Recent	35½	9	Male
34	June 22, 6 p. m.– June 23, 8 a. m.	June 27, 11 a. m.	June 30, 4 p. m.	?	July 11–12	July 18, 7 p. m.– July 19, 10 a. m.	July 28, 6 p. m.– July 29, 9 a. m.	26	10	Female
35	June 23 11 a. m.-4 p. m.	June 27–28	?	July 10–11	July 16–17	July 23, 11 a. m.– July 24, 9 a. m.	Aug. 2, 7 p. m.– Aug. 3, 9 a. m.	30½	9	Female
*36	June 24, 10 a. m.	June 28–29	July 3, 3 p. m. Just molted	July 6–7	July 14–15	Aug. 16, 12 m.– Aug. 17, 9 a. m.	Aug. 26, 11 a. m.	53½	9½	Male
37	June 26, 2–3 p. m.	?	July 5, 11 a. m. Just molted	July 10–11	July 14–15	July 24, 6 p. m.– July 25, 9 a. m.	Aug. 3, 2 p. m. Just adult	38	9½	Male
38	June 26, 3–4 p. m.	July 1, 1 p. m. Just molted	July 5–6	July 11, 12 m. Just molted	July 16–17	Aug. 1, 9 a. m.	Aug. 10, 10 a. m.	36	9	Male
39	June 27, 2–3 p. m.	July 2–3	July 5–6	July 10–11	July 17–18	July 25, 12 m.– July 26, 10 a. m.	Aug. 4, 10 a. m. Recent	28½	10	Male
40	June 27, 2:30 p. m.	?	July 5–6	July 10–11	July 16–17	July 24, 6 p. m.– July 25, 9 a. m.	Aug. 3, 2 p. m. Just emerged	27½	10	Male
41	June 27, 11:30 a. m.	July 3, 3 p. m. Recent	?	?	?	Aug. 3, 10a. m. Very recent	Aug. 12, 9 a. m. Emerging	37	9	Male
42	June 27 1–2 p. m.	?	?	?	?	July 30, 11 a. m.– July 31, 9 a. m.	Aug. 9-10	33½	?	Male
43	June 28, 1–4 p. m.	?	?	?	?	July 25, 6 p. m.– July 26, 9 a. m.	Aug. 4, 9 a. m. Emerging	27½	9¼	Female
44	June 28, 11–12 a. m.	July 3–4	July 11–12	July 16–17	July 25–26	Aug. 10, 12 m. Beetle 1 day old	Aug. 18, 9 a. m.	42	?	Female
45	June 28, 1–4 p. m.	?	?	?	?	July 24 11 a. m.-1 p. m.	Aug. 3, 9 a. m. Quite recent	26	9¾	Male
46	June 28, 11–12 a. m.	?	?	?	?	July 25, 6 p. m.– July 26, 10 a. m.	Aug. 4, 10 a. m. Emerging	27½	9¼	Male
47	June 28, 1–4 p. m.	?	?	?	July 21–22	Aug. 1, 6 p. m.– Aug. 2, 10 a. m.	Aug. 10, 11 a. m. Just adult	34½	8½	Female
48	June 28, 11–12 a. m.	July 3–4	?	?	?	July 27 3 p. m.-5:30 p. m.	Aug. 6, 11 a. m. Just emerging	29	9¾	Female
49	June 29, 2:30 p. m.	?	?	?	July 23, 3 p. m. Recent	Aug. 5 10 a. m.-2 p. m.	Aug. 15, 10 a. m. Beetle 24 hrs. old	37	?	?
50	June 29, 10–12 a. m.	July 3–4	?	?	? ?	July 29 10 a. m.-12 m.	Aug. 7, 9 a. m. Emerging	30	9	Female

*A 5th molt was found on Aug. 14th, but may have been shed two or three days earlier. Result of poor food.

RECORD OF DURATION OF LAVAL AND PUPAL STAGES—*Continued.*

Record No.	Date of Hatching.	Date of Shedding 1st Molt.	Date of Shedding 2d Molt.	Date of Shedding 3d Molt.	Date of Shedding 4th Molt.	Date of Pupating.	Date Adult Emerged.	No. of Days Laval Stage.	No. of Days Pupal Stage.	Sex of Beetle.
51	July 2 9 a. m.–1 p. m.	?	July 12	?		July 30, 6 p. m.– July 31, 9 a. m.	Aug. 10 Over 24 hrs. old	28½	?	Female
52	July 1–2	?	July 12	July 17	July 20	Aug. 4, 7 p. m.– Aug. 5, 9 a. m.	Aug. 13, 5 p. m. Aug. 14, 9 a. m	34	9	Female
53	July 4–5	?	July 16–17	July 21–22	July 25–26	Aug. 8–10	August 16–17	35	?	Female
54	July 4, 7 p. m.– July 5, 9 a. m.	?	?	?	July 26, 12 m.	Aug. 5, 5 p. m.– Aug. 6, 9 a. m.	Aug. 14, 5 p. m.– Aug. 15, 9 a. m.	32	9	Female
55	July 7, 10–12 a. m.	July 12–13	July 16–17	July 20	?	Aug. 2 11 a. m. 2 p. m.	Aug. 11, 11 a. m. Just emerging	26	9	Female
56	July 8 11 a. m.–3 p. m.	?	July 17, 2 p. m. Just molted	July 22–23	July 29	Aug. 10, 2 p. m. Over 24 hours	Aug. 17, 2 p. m. Quite recent	31	?	Female
57	July 8 11 a. m.–5 p. m.	?	July 18–19	July 22–23	July 28–29	Aug. 8–10	Aug. 16, 11 a. m. Just emerging	31	?	Female
58	July 8, 9 a. m.	?	?	?	?	Aug. 6, 10 a. m.– Aug. 7, 11 a. m.	Aug. 15, 10 a. m. Quite recent	30	8½	Female
59	July 8 11 a. m.–5 p. m.	?	July 18–19	July 22, 12 m. Just molted	July 26–27	Aug. 4, 7 p. m.– Aug. 5, 9 a. m.	Aug. 14–15	28	?	Female
60	July 8 11 a. m.–5 p. m.	?	July 16–17	July 21, 5 p. m. Just molted	July 28–29	Aug. 8–10	Aug. 16, 9 a. m. Emerging	31	?	Male
61	July 12, 9–10 a. m.	?	?	Aug. 1, 10 a. m. Recent	Aug. 10, 3 p. m. Recent	Aug. 17, 2 p. m.– Aug. 18, 9 a. m.	Aug. 27, 11 a. m. Recent	36½	9½	Male
62	Aug. 3, 9 a.m.–12 m.	?	?	Aug. 27–28	Sept. 4–5	Sept. 16–18	Sept. 27, 3 p. m. Quite recent	44	?	Female
63	Aug. 7, 2–4 p. m.	?	Aug. 18–19	Aug. 24, 10 a. m. Very recent	Sept. 4, 11 a. m. Recent	Sept. 11, 3 p. m.– Sept. 12, 12 m.	Sept. 23, 11 a. m. Just adult	36	11½	Female
	Approximate Average No. Days for Larval Stage for 63 Larvæ							33⅔		
	Approximate Average No. for Pupal Stage for 53 Pupæ								$9\frac{1}{9}$	

(A question mark (?) indicates that a close record was not secured.)
(A double date indicates that molt occurred between the hours indicated or at night when no hours are given.)

(These specimens were not often disturbed to secure exact date of molts.)

Rec. No.	Date of Hatching.	Date of 1st Molt.	Date of 2d Molt.	Date of 3d Molt.	Date of 4th Molt.	Date of Pupation.	No. Days Larval Stage.
64	June 2, 6 p. m. to June 3, 9 a. m.	?	?	?	?	July 14, 5 p. m. Just pup'd.	32
65	July 8, 11 a. m. to 3 p. m.	?	July 17–18	July 24, 1 p. m. Recent	July 31, 2 p. m. Recent	Aug. 16, 1 p. m. to 3 p. m.	39
66	July 8, 3 p. m. to 6 p. m.	?	?	?		Aug. 10, 7 p. m. to Aug. 11, 9 a. m.	33
67	June 10, 9 a. m. to 5 p. m.	June 15–16	June 19–20	June 30, 4 p. m.–July 1, 10 a. m.	July 4–5	July 12, 10 a. m. to July 13, 10 a. m.	32
68	June 9, 12 m. to 6 p. m.	?	?	July 7–8	July 10–11	July 19, 2 p. m. to 5:30 p. m.	30
69	June 22, 12 m. to 6 p. m.	?	July 5, 11 a. m. Just molted	July 10–16	July 17–18	Aug. 2, 10 a. m. to Aug. 3, 9 a. m.	41
70	June 22, 8 a. m. to 9 a. m.	June 26, 11 a. m. Recent	June 30, 10 a. m. to 4 p. m.	?	?	July 26, 12 m. to July 27, 10 a. m.	35½
71	June 22, 6 p. m. to June 23, 9 a. m.	?	?	?	?	Aug. 12–14	About 52
72	June 23, 11 a. m. to 4 p. m.	?	?	?	?	July 20, 10 a. m. to July 21, 9 a. m.	27½
73	June 26, 12 m. to 3 p. m.	July 1, 1 p. m. Just molted	?	?	?	July 31, 4 p. m. Just pupated	35
74	July 24, 9 to 10 a. m.	?	?	?	?	Aug. 22–23	About 30
75	July 24, 9 to 10 a. m.	?	?	?	?	Aug. 24–26	About 32
76	Aug. 3, 11 a. m. to 12 m.	?	?	?	?	Sept. 9–11	About 37
77	Aug. 3, 9 a. m. to 12 m.	?	?	?	?	Aug. 25–26	About 22
78	Aug. 3, 9 a. m. to 12 m.	?	?	?	?	Aug. 24–26	22
79	Aug. 11, 1 p. m. to 6 p. m.	?	?	?	?	Sept. 5, 4 p. m. to Sept, 6, 10 a. m.	25
80	Aug. 10, 5 p. m. to Aug. 11, 10 a. m.	?	?	Aug. 24, 11 a. m. Just molted	?	Sept. 3, 9 a. m. to Sept. 4, 10 a. m.	24
81	Aug. 28, 5, p. m. to Aug. 29, 9 a. m.	?	?	?	?	Sept. 27, 11 a. m. to 3 p. m.	29½

Approximate Average No. Days for 18 Larvæ 32

A discussion of the larval development recorded in the above table will be found in connection with additional records of larval development in the following table. These latter specimens were not reared to the beetle stage because of the pupæ dying from one cause or another, or being used for other purposes. Some of the pupæ were preserved for future study of the pupal stage.

Approximate Duration of Larval Stage of 81 Specimens.

From the above tables it is learned that the larvæ numbered from 1 to 63 took an average period of 33 2-3 days from hatching to pupation.

Larvæ Nos. 64 to 81 took an average of 32 1-9 days, which is only a little less than the first sixty-three.

The last eighteen were not often disturbed for the purpose of obtaining the exact date of molting, hence they may be considered as developing practically without interference. This would seem to prove that the larvæ numbered 1 to 63, were not materially retarded by being so frequently disturbed. Thirty-three days or slightly less, may therefore be considered as a correct average for larval development.

Partial Records of Larval Development.

As already stated, in addition to the larvæ numbered 1 to 81, which were in all instances reared to maturity and the date of pupation recorded, 208 other larvæ were kept until after one or more molts had been secured. These records, a portion of which are shown in the following table, serve to furnish additional information on which the average age of the larvæ at the time of molting may be determined.

In the following table only the closest records obtained are recorded. While the table indicates a wide variation for the age of larvæ at the time of molting, the writer believes that it represents what actually occurs in the field under normal conditions.

The larvæ were reared in short sections of corn stalks and always kept in an outdoor wire-screened cage where the temperature conditions were nearly normal.

PARTIAL RECORD OF LARVAL DEVELOPMENT.

(All of these larvæ were either killed, died or formed imperfect pupæ.)

Record No.	Date of Hatching	Approximate Date of 1st Molt.	Approximate Date of 2d Molt.	Approximate Date of 3d Molt.	Approximate Date of 4th Molt.
83	June 2, 4:30 p.m.	June 6, 4 p. m. Just molted	(Killed June 16 Poor food.)		
86	June 6, 11 a. m.–12 m.	June 10–12. Not close	June 16, 12 m.–June 17, 9 a. m.	(Not kept after 17th.)	
89	June 10, 12 m.–6 p. m.	June 15, 5:40 p. m. Just molting	(Died on June 22–23.)		
92	June 13, 4 p. m.–6 p. m.	June 20, 9 a. m. Within few hrs.	July 1 (?)	July 7–8	July 12, 6. p. m.–July 13, 9 a. m.
114	June 22, 11 a.m.–3 p. m.	June 26–28	June 29–30	July 5, 11 a. m. Just molted	

Partial Record of Larval Development—*Continued.*

Record No.	Date of Hatching	Approximate Date of 1st Molt.	Approximate Date of 2d Molt.	Approximate Date of 3d Molt.	Approximate Date of 4th Molt.
115–124	June 22, 11 a. m.–3 p. m.	June 26, 1 p. m. One just mltd.	N. B.—(Only one of these ten larvæ had molted 1st time June 26, 1 p. m. Not observed later.)		
125–126	June 22, 8–9 a. m.	June 26, 12 m. Recently mltd.	?		
130–136	June 22, 11 a.m.–3 p. m.	?	June 30, 5 p. m. One, recently mltd.		
	N. B.—(Only one of these seven larvæ had molted the second time, June 30, 5 p. m. Not observed later.)				
144–145	June 22, 8–9 a.m.	?	June 30, 10 a. m.–4 p. m.		
147–148	June 22, 11 a.m.–3 p. m.	June 26, 1 p. m.–June 27, 10 a.m.	July 3, 11 a. m. Recently molted		
149	June 22, 11 a. m.–3 p. m.	?	July 1, 12 m. Just molted		
170–180	June 23, 12 m.–4 p. m.	June 27, 10 a. m. Two, recent	N. B.—(Only two of these eleven larvæ had molted 1st time, June 27, 10 a. m. Not observed later.)		
187	June 24, 10 a. m.	June 28, 6 p. m.–June 29, 2 p. m.	July 3, 3 p. m. Just molted	July 6, 4 p. m.–July 7, 11 a. m.	July 15, 12 m.–July 17, 2 p. m.
188–189	June 24, 10 a. m.	June 28, 10 a. m. Very recent	N. B.—(1st molt in less than 4 days.)		
193	June 26, 2–3 p. m.	June 30, 6 p. m.–July 1, 1 p. m.	July 5, 10 a. m. Just molted	July 11, 12 m. Just molted	July 18, 12 m.–July 19, 12 m.
194	June 26, 3–4 p. m.	July 3, 11 a. m. Very recent	July 6, 4:30 p. m. Just molted	July 11, 12 m. Just molted	July 17, 3 p. m.–July 18, 11 a. m.
195	June 26, 2–3 p. m.	June 30, 12 m.–5 p. m.	July 5, 11 a. m. Just molted		
203–205	June 27, 8–9 a.m.	July 1, 11 a. m. One, recent	N. B.—(Only one of these three larvæ had molted 1st time July 1, 11 a. m. Not observed later		
206–214	June 27, 9 a. m.–1 p. m.	?	July 7, 10 a. m. Seven, molted		
	N. B.—(On July 7, 10 a. m., find that seven of these nine larvæ are past 2d molt. Other two molted only once.)				
215	June 27, 9 a. m.	July 1, 11 a. m. Very recent	July 5, 11 a. m. Just molted		
235–239	June 28, 12 m.–4 p. m.	?		July 17, 10 a. m. All quite recent	
241–242	June 29, 2:30 p. m.	July 4, 11 a. m. Both recent	N. B.—(Another larva hatched at same time had not molted July 4, 11 a. m.)		
244	July 8, 11 a. m.–5 p. m.	?	July 18, 11 a. m.–July 19, 10 a. m.		
245	July 8, 11 a. m.–5 p. m.	?	July 16, 12 m.–July 17, 9 a. m.		
246	July 8, 9 a. m.	July 17, 2 p. m. Recent	N. B.—(This larva was vigorous and growing. It was killed accidentally on July 20th, and had not shed 2d molt at that date.)		
247	July 8, 9–10 a. m.	July 17, 2 p. m. Just molted	N. B.—(This larva was small, and growing slowly although in good food.)		
260	July 8, 11 a. m.–5 p. m.	?	July 18, 11 a. m. Just molted	July 22, 11 a. m. Quite recent	July 29, 11 a. m.–July 30, 10 a. m.
263	July 12, 8–10 a. m.	?	?	July 28, 10 a. m. Recently molted	
264–271	July 12, 8–11 a. m.	?	July 21, 3 p. m. Two, recent		
	N. B.—(Only two of these eight larvæ were past 2d molt July 21, 3 p. m. Not observed later.)				
281	Aug. 3, 8–12 a.m.	?	?	?	Aug. 26, 10 a. m.–Aug. 28, 10 a. m.

Partial Record of Larval Development—*Continued.*

Record No.	Date of Hatching	Approximate Date of 1st Molt.	Approximate Date of 2d Molt.	Approximate Date of 3d Molt.	Approximate Date of 4th Molt.
282	Aug. 3, 8–12 a.m.	?	?	?	Aug. 28, 10 a. m.–Aug. 29, 10 a. m.
283	Aug. 7, 2–4 p. m.	?	Aug. 31, 12 m.–Sept. 1, 10 a. m.	Sept. 8, 10 a. m.–Sept. 9, 10 a. m.	
285	Aug 11, 6 p. m.–Aug. 12, 8 a. m.	?	?	Aug. 26, 11 a. m. Just molted	
286	Aug. 12, 8–12 a. m.	?	?	Aug. 27, 6 p. m.–Aug. 28, 9 a. m.	

Note: In the above table as in the previous table of larval development, many of the records for molts were made at about 24 hour intervals, as indicated by the double dates. The words "quite recent" or "very recent" indicate that the larvæ had molted within a few hours of the time when molt was found.

Age of Larvæ at Time of Molting.

The development of the larvae whose rate of growth is recorded under individual record numbers from 1 to 286, allows an opportunity of securing the average number of days between each molt even though complete records are available for only a few.

In the following table the number of days from hatching to shedding of first, second, third or fourth molt, is compiled from the foregoing records of larval development, but only the close records are included in this compilation.

The record numbers in the following table correspond to those in the previous table of larval development.

Larval Development by Molts.

Where a close record of hatching was secured and the molt is recorded as occuring at night, the latter time is figured as midnight for the purposes of this table. In the same manner when the egg hatched at night the time is counted as midnight if a close record of molt was recorded.

Table Showing Number of Days from Hatching to Each Molt.

(A fifth molt, sometimes occurring, is not taken into consideration.)

Record No.	No. of Days from Date of Hatching to:							
	1st Molt.		2d Molt.		3d Molt.		4th Molt.	
	Days.	Hours.	Days.	Hours.	Days.	Hours.	Days.	Hours.
1	----------	----------	21	6	----------	----------	39	20
2	----------	----------	----------	----------	----------	----------	27	----------
4	4	18	17	18	27	18	33	6
5	----------	----------	----------	----------	----------	----------	25	----------
6	4	6	11	6	----------	----------	22	16
8	6	11	----------	----------	----------	----------	21	20

LARVAL DEVELOPMENT BY MOLTS—*Continued.*

Record No.	No. of Days from Date of Hatching to:							
	1st Molt.		2d Molt.		3d Molt.		4th Molt.	
	Days.	Hours.	Days.	Hours.	Days.	Hours.	Days.	Hours.
9	5	9	10	9	14	9	21	9
10	5				30	13	35	13
11	5	6			14	6	23	6
12	4	12	13	12	17	12	25	12
13	6		10				21	10
15			11	10	17		25	
16	6	12	14	12	19	12	27	12
18			10	6	15	6	24	6
19	4	6	10	8	17	6	20	6
20	6	14	10	14			20	14
23							27	9
24							19	12
25							34	10
27	6	11	10	11	19	11	27	11
28	4	3	7	16				
29	6	11	12	11	18	11	22	11
33	4	21	9	10	12	10	25	
35	4	11			17	11	23	11
36	4	14	9	6	12	14	20	14
37			8	21	14	10	18	10
38	4	20	9	8	15	4	20	8
39	5	10	8	10	13	10	20	10
40			8	10	13	10	19	10
41	6	4						
44	5	12	13	12	18	12	27	12
47							23	9
48	5	12						
49							24	0
50	4	12						
56			9		14	12	21	12
57			10	10	14	10	20	10
59			10	10	14		18	10
60			8	10	13		20	10
61					20		29	5
62					24	12	32	12
63			11	9	16	19	27	20
65			9	11	16		23	
67	5	11	9	11	20	11	24	11
69			12	20	18	9	25	9
70	4	2	8	4				
73	5							
80					23	12		
83	4							
86		10	12					
89	5	3						
92	6	12			24	6	29	6
115	4							
125	4	2						
130			8					
144			8	4				
147	4	11	10	20				
148	4	11	10	20				

Larval Development by Molts—*Continued.*

Record No.	No. of Days from Date of Hatching to:							
	1st Molt.		2d Molt.		3d Molt.		4th Molt.	
	Days.	Hours.	Days.	Hours.	Days.	Hours.	Days.	Hours.
149			9					
170	3	21						
171	3	21						
187	4	14	9	7	12	14		
188	4							
189	4							
193	4	9	8	20	14	22	22	9
194	6	20	10		14	20	21	9
195	4		8	20				
203	4	2						
206			10					
207			10					
208			10					
209			10					
215	4	2	8	2				
235					18	20		
236					18	20		
237					18	20		
241	4	20						
242	4	20						
244			10	10				
245			8	10				
247	9	4						
260			9	21	13	21	21	10
263					16			
264			9					
265			9					
282							25	14
285					14	12		
286					15	15		

Average records obtained from this table are explained below.

Average Age at Which Larvæ Pass Molts.

A close study of the above record of larval molts furnishes complete data of the average age of the larvæ at the time of casting the successive molts.

Briefly summarized the record is as follows:

1st molt, 46 records, average age 5 days and less than 1 hour.
2d molt, 50 records, average age 10 days and less than 9 hours.
3d molt, 41 records, average age 17 days and less than 6 hours.
4th molt, 46 records, average age 24 days and less than 15 hours.

Last molt,—change of pupa—average age (see page —) nearly 33 days.

The duration of each larval instar was therefore found to be as follows:

1st Instar (hatching to 1st molt), approximately.....	5 days.
2d Instar (1st molt to 2d molt), approximately......	5⅓ days.
3d Instar (2d molt to 3d molt), approximately......	7 days.
4th Instar (3d molt to 4th molt), approximately......	7⅓ days.
5th Instar (4th molt to pupation), approximately.....	8⅓ days.
Total average larval stage..........................	33 days.

Considering the large number of records on which the above figures are based, it appears that this may be taken as a fair average record of larval development. The writer firmly believes that the development in the field does not differ materially from the figures secured by this work.

Summary and Additional Notes on Larval Development.

The shortest recorded time for full larval growth was 22 days, for two larvæ hatched August 3.

The longest recorded time for full larval growth was 53 1-2 days, for a larva hatched June 24.

Slow growth is usually the result of poor food, rather than cool weather, at least from the early part of June to the early part of September.

Slow growth of larvæ is recorded under the discussion of "Partial Second Generation," (page 133) but it has no practical bearing on the life history of the first generation.

A great variation in the rapidity of larval development during different instars was often recorded. In some instances the larvæ grew slowly until after the third molt, and then grew rapidly until ready to pupate. With others the reverse was true. Some larvæ grew slowly after the second or third molt, but still matured normally.

The larvæ cease feeding from a period varying from two to five or more days before pupating. The larvæ that matured in the shortest periods recorded seemed to feed until the second day before pupating, while the slow maturing larvæ sometimes lay dormant, or only occasionally active for fully a week before pupating.

Pupa.

Larvæ under normal conditions always prepare a cell in which to pupate, either in their feeding channel, or in the earth just beneath.

The pupa, or resting stage, assumed by the larvæ at the average age of 33 days, requires practically nine days to mature and for the adult beetle to emerge therefrom. The figures to sustain this statement are found in the table entitled "Duration of Larval and Pupal Stages" on page —, and in the additional records given in the following table. These last records of the pupal stage were secured from pupae reared from larvae collected from cyperus plants in the fields around West Raleigh.

Twenty-seven adults were reared in this manner, but the exact duration of the pupal stage of some was not secured. This accounts for record numbers omitted in the following table.

Duration of Pupal Stage.*

Record No.	Date of Collecting Larva from Field.	Date of Pupation	Date of Maturing to Beetle Stage.	Sex of Beetle.	No. Days in Pupal Stage.
2	June 30 (large larva)	July 7 9:30 a. m.–11:30 a. m.	July 16 8 a. m.–11 a. m.	Female	9
3	June 28 (large larva)	July 5, 12 m.- July 6, 11 a. m.	July 13, 10 a. m. Only few hrs. old	Male	8
4	June 30 (large larva)	July 5, 12 m.- July 6, 12 m.	July 14, 5 p. m.- July 15, 10 a. m.-	Female	9
7	June 21 (medium larva)	July 10, 7 p. m.- July 11, 9 a. m.	July 20, 10 a. m. Just emerged	Male	9½
8	July 7 (large larva)	July 11, 5 p. m.- July 12, 9 a. m.	July 20, 10 a. m.- July 21, 10 a. m.	Male	9
9	June 15 (small larva)	July 13 12 m.–5 p. m.	July 22 11 a. m.–4 p. m.	Male	9
12	June 30 (medium larva)	July 16, 11 a. m.- July 17, 11 a. m.	July 25, 10 a. m.- July 26, 10 a. m.	Female	9
14	July 15 (full grown)	July 21, 10 a. m.- July 22, 10 a. m.	July 31, 5 p. m.- Aug. 1, 11 a. m.	Female	10
15	July 7 (large larva)	July 24, 10 a. m. Recently pupated	Aug. 3, 9 a. m. About 12 hrs. old	Male	9½
16	June 30 (large larva)	July 24, 2 p. m. Just pupated	Aug. 2, 6 p. m.- Aug. 3, 9 a. m.	Male	8½
18	July 7 (large larva)	July 19, 11 a. m.- July 20, 9 a. m.	July 29, 9 a. m. Just emerged	Female	8½
20	June 30 (small larva)	July 21, 6 p. m.- July 22, 9 a. m.	July 30, 10 a. m.- July 31 9 a. m.	Female	9
22	June 30 (small larva)	July 30 10 a. m.- July 31, 9 a. m.	Aug 9, 10 a. m.- Aug. 10, 9 a. m.	Female	10
24	July 28 (full grown)	July 31, 5 p. m.- Aug. 1, 9 a. m.	Aug. 9, 10 a. m.- Aug. 10, 10 a. m.	Male	9
25	July 28 (large larva)	Aug. 6, 11 a. m.- Aug. 7, 11 a. m.	Aug. 14, 9 a. m.- Aug. 15, 9 a. m.	Female	8
27	June 20 (small larva)	Aug. 25–26	Sept. 3–4	Female	8
Average Duration of Pupal Stage approximately					9

Note: (A more extensive record of pupal stage is iven in a previous table. Page —)

*These pupæ were reared from larvæ collected from cyperus plants in the field on the dates recorded.

Summary of All Records of Pupal Stage, With Additional Notes.

The last table gives the approximate pupal stage for 16 individual pupæ and the table on pages 117 to 120 gives a similar record for 53 individuals. The total average for both series, comprising 69 pupæ in all, is only a fraction above nine days.

Eight days approximately, is the shortest time in which the pupæ can mature, and ten days is the longest time.

The normal development of the pupa is not materially affected by heat or moisture conditions during the summer months. Many of those reared during the course of this work, were forced to pupate on dry soil, a procedure rendered necessary at times to avoid injury by mites.

Most of the pupæ transformed in a cell which was formed either in the corn stalk in which the larvæ matured or in the soil underneath their food.

The pupal stage is ordinarily assumed in a well formed cell, generally lined with the fiber of the plant in which the larva fed during its growth. In some instances the larve drags particles of fiber into the soil to line the cell for the pupa. In the field the pupa is frequently found in a compact earthen cell, not lined in any manner, except for having the inside smoothed and probably hardened with secretions by the full grown larva.

A pre-pupal stage is always noticeable. That is, the larva assumes an elongated, cylindrical form, while the body becomes somewhat stiff and rigid. This may be noticed for one or two days before the transformation to pupa takes place.

Life Cycle of Individuals From Egg to Adult.

The foregoing records of egg hatching, larval and pupal development and emergence of adult beetles may be summarized to show the average duration of the life cycle under normal summer weather conditions, as follows:

Average Duration of Life Cycle.

	Average.
Approximate average duration of egg stage..........	6 days.
Approximate average duration of first instar	5 days.
Approximate average duration of second instar	5⅓ days.
Approximate average duration of third instar	7 days.
Approximate average duration of fourth instar	7⅓ days.
Approximate average duration of fifth instar	8⅓ days.
Approximate average duration of pupal stage	9 days.
Total life cycle, egg to adult........................	48 days.

The above figures give the average life cycle secured from all the breeding records. It will be noted that the life cycle of 48 days is not based on the average between the extreme minimum and maximum records secured, but on an average of the total records. The average duration of the larval stage alone is 33 days, as already explained; if, however, we should take the average between the shortest larval duration of 22 days and the longest of 53 1-2 days, as given in a previous table, we would have 37 3-4 days for average larval development. This one illustration serves to prove that the average of the total figures secured from many records during the season, is what we need for a life history study of any insect.

The minimum life cycle, counting five days for the egg, twenty-two days for the larva, and eight days for the pupa, is only thirty-five days, which is certainly much below the average.

The maximum life cycle, allowing ten days for the egg, fifty-seven days for the larva and ten days for the pupa is seventy-seven days, or two and one-half months, a slow development that would perhaps never occur except with a few late individuals.

Enemies and Diseases of Larva and Pupa.

No internal parasites for either the larva or the pupa have been discovered. It is probable that none exist, except possibly in very exceptional cases.

Mites have proved to be a pest of both the larvæ and the pupæ in confinement, but field observations do not show that the same thing is true under perfectly normal conditions. During the breeding work, many larvæ are apparently killed, or worried so as to prevent regular growth, by a small mite identified by Mr. Banks as *Tyroglyphus americanus Bks.* These mites were often found on the bodies, or in their feeding channels, and usually such larvæ did not grow well. Very young larvæ were sometimes killed by the mites.

Both larvæ and pupæ were sometimes found with a portion of the body blackened, evidently by some fungus growth. However, no real evidence was secured to prove that the larvæ or pupæ were ever killed by fungus or bacterial disease.

Adult.

The adult beetle stage has been observed both in the field and in confinement. The first beetles collected during the latter part of June, 1910, were kept alive, as already stated, until March 1, 1911. At the present date, December, 1911, in the breeding cage where the life history work was conducted, there are now a number of beetles alive, which were collected May 26, 1911, and some of them are the ones whose egg-laying record has been recorded. There are also about fifty beetles which were reared from eggs during July, August, and September. Of the total number reared in confinement, that is, sixty-three, as shown in the rearing records, only one commenced to lay eggs for a second generation. The record of this one female is given in the latter part of this report under a discussion of "Partial Second Generation." The possibility of an extensive second generation is very remote, and we may, therefore, consider one generation each year as the normal condition.

Feeding Habit of Adult Bill-Bugs.

The beetles reared last summer during the breeding experiments commenced to feed about the fifth day after emergence. These beetles were usually in cells in which they could readily escape. A few matured in cells in the soil and did not emerge for about two weeks, but in such cases they commenced to feed the first day after appearing above ground. The beetles that mature in the field undoubtedly feed after emergence until cold weather drives them into hibernation. In the breeding cage the reared beetles fed on corn stalks supplied as food, until after the middle of October. Most of the beetles fed every day until that time.

Damage to young corn plants is caused by the beetles eating into the stalk at or below the surface of the ground, often making slits a half inch or more in length with their thin chisel-like beak, on the end of which the true biting jaws are located. Small plants are killed outright. Corn plants that have attained a height of eight or ten inches before being attacked are not usually killed, but grow crooked and dwarfed and never make a normal growth. The larger plants are also stunted by the larvæ feeding in the root, or in the stalk just above the root.

The writer has never discovered that the bill-bugs feed on any plants except corn, and species of *Cyperus.* Other writers state that bill-bugs feed on many sedges, which may be true, but such statements may have been based on the feeding of other species than *Sphenophorus callosus.*

The most natural position for the beetles when feeding is to stand head-downward, with the legs clasped around the food plant, and the beak buried more or less in the tissue of the plant. The powerful leg and foot hold is quite characteristic of these beetles. It requires a strong pull to remove beetles when they are settled for feeding.

Duration of Beetle Stage.

As has already been stated beetles collected on June 20, 1910, lived until March 1, 1911.

Those beetles represented the 1909 generation and must have matured during July, August or September of 1909. Considering that they matured on the first of September, 1909, and lived until March 1, 1911, their age was fully eighteen months at the time of their death. The writer believes that further experiments will prove that some beetles may live two years or more. The beetles that died on March 1, 1911, would no doubt have lived longer if they had not been disturbed to see how many were alive during the months of January and February, 1911.

At the present time, December 10, 1911, the writer has one beetle that matured between August 3 and 9, 1911, commenced to lay eggs August 26, 1911, laid twelve eggs before September 13, and is now alive, buried in earth in a jelly glass. With this exception none of the reared beetles showed any signs of mating or egg laying. All evidence points to the fact that the beetles normally mature and feed during the fall months, hibernate in the soil or in corn stalks (see discussion of hibernation), emerge in spring during March or April, commence egg laying about May 25, continue egg-laying for from two or four months, and finally die off during the late fall months or else hibernate and live at least a portion of the second winter. It is yet to be proved that any of the beetles live to emerge the second spring, but we have no evidence to prove that this does not sometimes occur.

Food Plants.

The larvæ of *Sphenophorus callosus* have been found in the following plants:

Corn, in all localities where bill-bugs have been observed.
Rice, in all localities where rice is grown in bill-bug sections which have been visited.
Cyperus flavicomus, at Raleigh, in large numbers.
Cyperus cylindricus, at Proctorville and Braswell. (Only few.)
Cyperus strigosus, at Lumberton and Chadbourn.
Cyperus overlaris, at Pembroke. (Many plants infested.)
Cyperus esculentus (common chufa), around West Raleigh. Very common in this locality, where the plants are known as nutgrass.

Corn, rice and the larger species of Cyperus are undoubtedly the main food-plants in North Carolina.

I have collected as many as ten adult beetles from beneath a single large plant of *Cyperus flavicomus* which in this section sometimes grows in clumps of ten or more plants. The field of *Cyperus esculentus* at

West Raleigh, where *Sphenophorus callosus* bred freely this past summer, consisted of plants that seldom grew large enough to support more than one larva. During the months of July and August larvæ of all sizes, and frequently pupæ, were found readily at the base of these plants.

Hibernation.

The bill-bugs hibernate ordinarily in the beetle stage. This statement is made without reservation and is based on many field observations during the winter of 1909-1910, when careful search on several occasions failed to reveal any eggs, larvæ or pupæ, in the field where bill-bugs were known to have bred during the previous falls. It has proved to be extremely difficult to find any bill-bugs in their winter quarters, but the total absence of larvæ and pupæ in the breeding places proves that the winter is not passed in either of those stages.

Only one record has been secured of actually finding the beetles in a place where they presumably pass the winter. On November 4 and 5, 1911, in company with Mr. J. A. Hyslop, of the National Bureau of Entomology, adult bill-bugs were found in corn stubble in a field on Harvey's Neck in Perquimans County. The trip to this field was made for the express purpose of trying to find the beetles, for it was assumed if any were found on that date that they would be in hibernation for the winter. After considerable search we located a dead beetle in a corn stalk. This beetle was at a point in the stalk about even with the surface of the ground. Soon afterward we found another dead beetle in a similar location. On the second day three live beetles were found in corn stalks in a field where serious bill-bug damage had occurred during the summer. Apparently these beetles had matured late and had not attempted to escape. We consider this to be proof of the hibernation actually occurring in the corn stalks. The beetles were in the stalk near the roots, where the larva had fed and transformed.

During these two days when beetles were found in corn stalks, we also searched for the beetles, and the immature stages, in Cyperus plants, but without success. In fact, there were only a few Cyperus plants found in which *Sphenophorus* larvæ had lived. The writer believes, however, that the bill-bugs had bred in Cyperus in these fields in plants that had died down and become invisible.

Hibernation must also occur in the soil, or under the protection of some material in the fields, as well as in corn stalks. The breeding of beetles during the past summer, when every reared specimen emerged and fed nearly every day thereafter until the middle of November, shows that it is the natural thing for the beetles to come out and feed after maturity. If this is true the majority of the bill-bugs are not hibernating in corn stalks unless they crawl into the stalk when cold weather commences. That this actually occurs is extremely doubtful. The beetles found in the corn stalks had certainly never emerged and no beetles were found under conditions to indicate that they had crawled into the stalk.

On November 5, 1911, Mr. Hyslop found one healthy live pupa in a corn stalk. This indicates a possibility of the pupæ living in that situation all winter. The rearing records, however, do not indicate that pupæ are liable to live all winter. This point needs further investigation, but in view of present knowledge we may consider that only the mature beetles normally live during the winter.

The writer has searched for the beetles in winter quarters in fields at Lumberton, Chadbourn, Braswell, Pembroke, and other places, including the fields around West Raleigh, where many bill-bugs bred during the last two seasons. Without recording details of the work it may be stated that the beetles have never been discovered during the winter months, that is, December to March inclusive, except in one instance at Chadbourn, when a single specimen was taken in the edge of a rice field on March 29, 1911. On that date one beetle was found in a clump of grass, where it was moving about, hence it was not exactly in hibernation. Sticks, stones, logs, dead grass and weeds, brush, and, in fact, every movable thing in the field, have been overturned in the search for beetles in hibernating quarters other than corn stalks.

Summary of Seasonal Life History.

Without considering a partial second generation, which is only of minor importance, the seasonal life history of the corn bill-bugs may be stated as follows:

Eggs are first laid about May 20, in corn plants or the larger species of Cyperus and possibly in other sedges. The eggs require an average of six days for hatching. Egg laying continues until the latter part of September.

The larvæ feed in the stalk or root of the plants and become full grown in an average period of about thirty-three days.

Larvæ of all ages occur from June to after November 30, but the majority are full grown before November 1.

The pupæ occur in cells in the stalk of the food plant or in the soil underneath the roots. Nine days is the average duration of the pupal stage.

The beetles mature and usually emerge and feed during the months from July 1 to November 1 or later. These beetles do not often mate and lay eggs until the following spring, after emerging from hibernation in which they pass the winter.

Partial Second Generation of Sphenophorus callosus.

In the preceeding report, covering the breeding experiments with this species, mention is made of a partial second generation, based on the record of one reared female that laid fertile eggs, the larvæ from which were reared to different ages. No pupæ were secured from these larvæ, but the writer believes this to be due to improper food and handling, rather than to the inability of the larvæ to attain full growth and pupate. As no beetles of the second generation were actually reared this can not really be considered as a true second generation. The reader will understand, however, that the larvæ under suitable conditions would have matured and pupated, and adults might then have been secured. The writer believes that a partial second generation does occur occasionally.

During the past season, as the records show, 56 female bill-bugs were reared from eggs or from larvæ collected from Cyperus plants. Only one of these 56 females commenced to lay eggs. This one female was secured between August 3 and 9—the exact date, unfortunately, not recorded—and after feeding on corn plants for about two weeks she commenced to lay eggs between August 26 and September 1. On the latter date, when the eggs were found, this beetle was confined with two other females and two males. These three females were at once separated and watched carefully for several weeks to prove that only one continued to lay. Previous to September 1, and for several weeks afterward, all the reared beetles were furnished fresh food every two or three days, and this food carefully examined when removed. In this way it was ascertained that no other female except the one mentioned, ever laid eggs, and, in fact, no sign of mating was ever observed.

Record of One Female Which Laid a Few Eggs For Second Generation in 1911.

Five eggs were first found on September 1, when the female was about three or four weeks old. Her egg-laying record was as follows:

Between August 21 and September 1, laid	5 eggs.
September 2, laid	1 egg.
September 3, laid	0
September 4, laid	2 eggs.
September 5 and 6, laid	0
September 7, laid	1 egg.
September 8, laid	0
September 9, laid	2 eggs.
September 10 and 12, laid	0
September 13, laid	1 egg.
From September 13 to October 27	0
Total	12 eggs.

This female was kept under observation until October 27, but laid no eggs after September 13. On October 27 she was alive and active, and on November 20 when last seen, she was still alive, but buried in soil preparatory to hibernating there during the winter.

The eggs secured were hatched in about six or seven days. No accurate record was kept, but all the eggs hatched as quickly as did eggs of the first generation, which were still being secured during the same period.

Partial Larval Development of Second Generation.

Nine larvæ were reared to partial development, but on account of improper food none of them matured. The individual records of some of these larvæ are given below:

Larva No. 1.—Hatched September 2-4; placed in corn stalk September 4, 9 a. m. Not seen until September 15, when it was found dead after growing only a little and evidently past first molt. Death evidently due to hard, dry food.

Larva No. 2.—Hatched September 4-5; placed in corn stalk September 5. Not seen again until October 10, when it had attained about two-thirds usual size of mature larva; next seen on November 14, when it was still alive but not feeding, and had not grown much since October 10; found dead November 20. Death probably due to improper food.

LARVA No. 4.—Hatched September 26; placed in food about 1 p. m. September 16, seems to be feeding and growing naturally. September 27, found dead; cause unknown; larva does not look discolored; had passed second molt.

LARVA No. 7.—Hatched September 19-20; placed in food September 20. September 29, feeding and growing. October 2, larva killed accidentally.

The writer wishes it understood that the larvæ of the second generation were fed in sections of large corn stalks which evidently did not furnish good food. As this work was not anticipated no young corn plants had been provided for and it was found difficult to secure suitable food for rearing the larvæ. In the field the beetles may lay eggs in large Cyperus plants in which the larva could get the proper food. If that occurs there is every reason to suppose that adultts of the second generation may occasionally mature. The fact that larvæ were reared to practically full growth in poor food shows that they might readily mature if good food were obtainable.

There is only a slight probability, however, that any extensive second generation usually occurs. The notes recorded above, if considered in connection with all the rearing records, indicate clearly that it is not usual for the females to lay eggs for a second generation.

BIOLOGICAL RECORD OF LITTLE GRASS BILL-BUG.

Sphenophorus Parvulus.

By

R. I. Smith.

The study of the life history of *S. parvulus* conducted during the season of 1911 was originally commenced as a minor part of the Adams Fund Project entitled "Biological Investigation of *Sphenophorus callosus* and Other Injurious Species of This Genus Occurring in North Carolina," upon which the writer worked almost exclusively from April to November, 1911. The biological records with *S. callosus* have been recorded in a separate article.

The little grass bill-bug is not known to be a serious pest in North Carolina, although it may do more damage than we are aware of. The present report covers only a life history study of this species. The writer has no data concerning the damage caused by this insect. The North Carolina Station collection of insects did not, before this year, contain any specimens of this insect, although it was known to occur in the State.

The notes and records which follow are submitted as a scientific report of the egg-laying habits, egg-laying record, and larval and pupal development; also the number of generations occurring annually. The conditions under which this work happened to be undertaken, together with the records secured, serve to make this report of peculiar interest, as a biological problem.

On May 19, 1911, one small beetle of this species was collected from a low ground corn field on Rocky Creek, less than one-half a mile from the writer's office and laboratory. This specimen proved to be a fertile female which commenced to lay eggs on May 21 or 22. On the latter date three eggs were found in the corn stalk which had been furnished the beetle for food. At that time, and for the remainder of the season, this lone female was confined in a jelly glass and provided with sections of green corn stalk for food. Three other beetles of the same species were collected about the same time, but they all died within a few weeks; hence the season's work was based on the record of this lone female and her progeny.

Egg-laying Record of One Female, S. Parvulus.

As already stated, the female, collected May 19, commenced to lay eggs on May 21 or 22. After the latter date, when the first three eggs were found, this beetle was carefully fed and tended, in order to secure her full egg-laying record. A daily record, with only a few exceptions, was secured, as shown in the table which follows. Green corn stalk was the food provided, in which all the eggs were placed.

During this egg-laying existence the beetle was kept in a jelly glass, in a wire screened room used for an outdoor laboratory. Her environment was somewhat artificial, but moisture and temperature conditions were about normal.

Daily Egg-laying Record of One Female, Collected May 19, From Corn Field.

Date in 1911.	Number of Eggs.	Date in 1911.	Number of Eggs.	Date in 1911.	Number of Eggs.
May 22	3	July 2- 3	missed	August 11	2
May 23	1	July 4	1	August 12	3
May 24	1	July 5	1	August 13–15	1
May 26	1	July 6	1	August 16	1
May 27	1	July 7	5	August 17	5
May 28	2	July 8	4	August 18	4
May 30	1	July 10	3	August 19	4
May 31	2	July 11	4	August 20	1
June 1	1	July 12	3	August 21–23	2
June 2	1	July 13	4	August 24	4
June 4	1	July 14	1	August 25–26	1
June 5	1	July 15	1	August 27	5
June 7	1	July 16		August 28	3
June 8	3	July 17	1	August 29	4
June 9	1	July 18	4	August 30	4
June 11	3	July 19	3	August 31	2
June 12	3	July 20	2	September 1	1
June 13	1	July 21	4	September 2	2
June 14	1	July 2	1	September 4	3
June 15	2	July 23	7	September 5	1
June 16	2	July 24	4	September 6	2
June 17	1	July 25	3	September 7	1
June 18	3	July 26	4	September 8	2
June 19	2	July 27–28	5	Sept. 9–11	2
June 20	2	July 29	3	September 13	1
June 21	2	July 30	3	September 15	1
June 22	2	July 31	1	September 19	1
June 24	7	August 1	3	September 20	1
June 25	1	August 2	3	September 22	1
June 26	1	August 3	4	September 23	1
June 27	3	August 4	4	September 25	1
June 28	2	August 5	2		
June 29	1	August 6	4	September 29	2
June 30	3	August 7	3	October 7	1
July 1	4	August 8–9–10	17	October 8–27	0
				Total	255

Notes Concerning Egg-laying Record.

Two hundred and fifty-five eggs were laid between May 19 and October 7, a period of 142 days, or over four and one-half months. Seven eggs was the greatest number laid in any twenty-four hour period.

The female was alive and healthy on October 27, when daily observations were discontinued; and she was still alive but lying buried in the soil on November 20, when last seen.

In the above record where a daily date is omitted entirely it means that no eggs were laid, but when the egg record for two or three days is united it means that the eggs were not removed until the latter date.

Egg-hatching Record.

The eggs secured during the laying record recorded above proved to be fertile and many of them were hatched to secure larvæ for rearing. Only a very few close egg hatching records were recorded; from these the average incubation period proved to be about seven days during the early days of June, and about six days during July and August. During the last of September, when much cooler weather prevailed, some eggs took fully eleven days to hatch.

The average incubation period for warm summer weather is no doubt as low as six days, or about the same time required for eggs of *S. callosus* to hatch.

Rearing Records From Egg to Beetle.

The larvæ, immediately after hatching, or within less than twenty-four hours were placed carefully in a corn stalk for the purpose of determining the length of the larval stage and for rearing pupæ and adult beetles. All of the larvæ were reared in a section of corn root taken from the field. The plant was usually cut off three or four inches above the root. In this short section a hole was cut into one side, the newly hatched larvæ carefully introduced, after which the opening was closed by replacing the surface of the piece removed; this was then secured by a rubber band. These sections of corn plants were usually kept on moist earth. Frequent observations were made to determine the location and development of the larvæ. It was found difficult to get the young larvæ established, but out of a considerable number handled in this manner I succeeded in rearing four beetles, which matured in a healthy condition and commenced to feed within a few days after emergence. Three pupæ were also reared, but died before transforming to the beetle stage. Over twenty additional larval records were secured, representing specimens that lived for a short time only, or became apparently full grown, but failed to pupate from one cause or another.

These statements refer to larvæ of the first generation only, the progeny of the female whose egg-laying record has been recorded. A partial second generation was reared, as recorded farther on.

The larvæ of this species are small and delicate, when first hatched, rendering it difficult to watch their growth in corn stalks without injuring some specimens, and doubtless causing a slow growth of some that mature in spite of being frequently disturbed. For this reason it is possible that the records of larval development in the following tables may show a slower growth than really occurs in the field.

Rearing Records.

(For first generation in 1911, including all notes of importance made concerning each specimen.)

Nos. 1 to 4, inclusive, reared from egg to beetle stage.
Nos. 5 to 7, inclusive, reared only to pupa stage.
Nos. 8 to 21, inclusive, are records of partial larval development.

RECORD No. 1.—Egg laid June 11 after 6 p. m.; hatched June 19 after 6 p. m.; pupated July 29-30; adult found August 10.

RECORD No. 2.—Egg laid June 29-30; hatched July 6, before 10 a. m.; pupated August 15; adult August 24, 9 a. m.

RECORD No. 3.—Hatched July 4-5; pupated August 12, 9 a. m.; adult just emerged August 20, 10 a. m.

RECORD No. 4.—Hatched July 26 to 28; pupated September 25; adult October 4.

RECORD No. 5.—Egg laid August 3-4; hatched August 10-11; pupated September 10-11.

RECORD No. 6.—Egg August 3-4; hatched August 10-11; pupated September 17-18.

RECORD No. 7.—Egg August 28-29; hatched September 4-5; pupated about October 20.

RECORD No. 8.—Hatched July 18-19; full grown about August 16; died August 30.

RECORD No. 9.—Hatched August 20-21; about full grown August 17; dead August 24.

RECORD No. 10.—Hatched July 29-30; full grown September 4; died September 11.

RECORD No. 11.—Hatched July 29-30; nearly full grown September 29; dead October 10.

DECORD No. 12.—Hatched August 3-4; nearly grown August 26; dead August 29.

RECORD No. 13.—Hatched September 8, 10 a. m.; about full grown October 14; dead November 6.

RECORDS Nos. 14 TO 21, INCLUSIVE.—The larvæ numbered from 14 to 21 were hatched on dates ranging from June 8 to September 30, but none of them thrived in their artificial environment. Their records are not sufficiently complete to be recorded in detail.

SUMMARY OF LIFE CYCLE AS SHOWN BY RECORDS.

The record numbers correspond to those in preceding records.

The record by days is approximate, not exact.

Record Numbers	1	1	3	4	5	6	7
Number of Days for Egg Hatching	6	6½	?	?	7	7	7
Number of Days for Larval Growth	40	41	33	60	34	38	46
Number of Days for Pupal Stage	9	9	8	9½	?	?	?

This table shows that the larval stage for the seven specimens recorded varied from 31 to 60 days, a condition which the writer believes to be comparable with normal field conditions.

The pupal stage undoubtedly covers about nine days, dependent somewhat on heat and moisture conditions. Moisture, however, does not seem to be as necessary as warmth, for some of the pupa developed normally in a very dry cell.

Partial Second Generation.

During the season of 1911 four beetles of this species were reared from eggs, as recorded in the first portion of the report on this insect. Of these four beetles one commenced to lay eggs for a second generation. The eggs secured were hatched and an attempt was made to rear the larvæ to maturity. This attempt, however, was unsuccessful on account of not being able to furnish the larvæ with proper feed. Over fifteen larvæ were reared to partial maturity; seven of them reached full growth but did not pupate; one larva attempted to pupate, but died in the attempt. The work, however, shows that a second generation may occur if the proper conditions prevail.

Record of One Female Which Was Reared and Laid Eggs for a Second Generation.

This female matured about August 20, commenced to feed August 26, and had laid four eggs on September 6. Including the eggs found on that date her record was as follows:

September 6, found.......	4 eggs.	September 18, found.......	3 eggs.
September 7, found.......	1 egg.	September 21, found.......	1 egg.
September 9, found.......	6 eggs.	September 23, found.......	1 egg.
September 11, found.......	5 eggs.	September 25, found.......	2 eggs.
September 13, found.......	4 eggs.	September 27, found.......	0
September 16, found.......	0		
		Total laid in 19 days.....	27 eggs.

After September 27 the female was observed frequently until October 23, but she did not lay any more eggs. She was alive and active on November 14, but was found dead on December 8. Hence the opportunity is lost to determine if a female that lays eggs in this manner is capable of living through the winter and continuing to lay eggs again the following spring.

This female was reared in a short section of corn stalk, and, after maturity, was kept in a jelly glass, on rather dry earth. Her food was short sections of green corn stalk, replenished every two or three days. Afte the first of October it was difficult to get succulent corn stalks for food, but it seems probable that the beetle could not have found a much better food supply in the field.

Brief Notes on Rearing Larvæ of Second Generation.

Fifteen larvæ were reared to partial maturity. Of this number one attempted to pupate, but failed; it was found dead with larval skin partly shed. Six larvæ reached about full growth but died because of poor food evidently. The remainder never attained half size.

I. STUDIES IN COTTONSEED MEAL INTOXICATION.[1]

As to Pyrophosphoric Acid.

By W. A. Withers and B. J. Ray.

With the Collaboration of R. S. Curtis and G. A. Roberts.

The injurious effect from the continuous feeding of cottonseed meal to calves and swine has been known for years. The cause has been regarded by various investigators[2] as lint, oil, high protein content, a toxalbumen, cholin, betain, resin and decomposition products. Crawford[3] in a preliminary paper published in March, 1910, states that "The chief poisonous principle in certain cottonseed meals is a salt of pyrophosphoric acid." Crawford's conclusion is based upon the study of an extract obtained by digesting the meal at body temperature one day with pepsin and one day with pancreatin. He fed with a catheter extracts of cottonseed meal, these extracts corresponding to amounts of meal very much in excess of those which would be fed ordinarily. He made no study of undissolved residues.

We began the study of the subject August 19, 1908, and since that time have used many solvents in our efforts to extract the toxic substance. The undissolved residue having proved toxic in every case we decided to investigate the residue undissolved by the pepsin pancreatin treatment. We also tried other feeds which bear upon the question.

The animals selected were rabbits. Our normal daily feed for each animal was 15 grams of cottonseed meal, or an amount of some fraction equivalent to 15 grams of meal. As the rabbits used averaged about 1.5 kilos the daily feed corresponds to 10 grams per kilogram of initial live weight. The feed refused was estimated and correction made. Each animal was allowed peavines, cabbage leaves or other green feed each morning. We mixed molasses with the cottonseed meal, and when some fraction of the meal was being fed the portion of meal removed was replaced by an equivalent weight of wheat bran. Six controls were run during the entire time of the experiment and all the control animals lived. The feeds, daily and total, are all calculated to the equivalent in grams of cottonseed meal per kilo of initial weight of animal.

Feed No. 67. Pepsin and Pancreatin Extract—Forced Feeding. Started June 2, 1910.

Raw cottonseed meal was digested one day each with pepsin and pancreatin. The mass was filtered, and the filtrate concentrated to small volume. The solution was fed through a catheter in amounts corresponding to 200 grams of meal.

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[1]This paper was read before the Biological Section of the Am. Chem. Soc. at its Washington meeting, December 1911, (except the results of Feed No. 182). This paper appears in the Journal of Biological Chemistry, March, 1913.

[2]Journal of Pharmacology 1, (1910) 547.

[3]Experiment station record 22 (1910) 502.

Nine rabbits were taken, varying in weight from 1461 to 2240 grams, average 1752. All lost in weight an average of 123 grams. Two were made very sick, but survived; two showed no ill effect except loss in weight, and five died. The amount fed corresponded to ten times our normal feed of cottonseed meal. The P_2O_5 in the feed was 2.22 gms.

Feed No. 73. Sodium Pyrophosphate. Started May 16, 1911.

Sodium pyrophosphate was prepared in the laboratory by igniting disodium phosphate. The product responded to the tests for pyrophosphate and for freedom from orthophosphates. 4.157 grams corresponded to 2.22 grams P_2O_5, the amount contained in the pepsin pancreatin extract of 200 grams of meal (Feed No. 67). The pyrophosphate for each animal was dissolved in 65 c.c. of water and fed through a catheter.

One rabbit weighing 2070 grams was fed on May 16, 1911, and died that night. Another rabbit weighing 1456 grams was fed on July 11, 1911, and died in 31 minutes.

The results with our feeds 67 and 73 indicate that the pepsin pancreatin extract of 200 grams of meal is generally toxic when given at one feeding and that the $Na_4P_2O_7$ corresponding to the amount of P_2O_5 in that amount of meal is toxic if administered at a single feeding.

Feed No. 120. Cottonseed Meal. Started April 23, 1191.

Twelve rabbits were taken whose initial weight ranged from 970 to 2560 grams, the average being 1559 grams. All the animals died within from eight to 21 days, average 13 days. The average loss in weight was 379 grams. The total amount of meal consumed by each animal ranged from 105 to 225 grams, average 157 grams. The total amount eaten was practically 100 grams per kilo of initial weight of the animal, making an average daily consumption of meal equivalent to 7.7 gms. per kilo of animal. These figures indicate the degree of toxicity of the meal towards the animals under the conditions of the experiment. There were 2.76 grams of P_2O_5 in the average feed or 0.21 grams in the daily feed.

Feed No. 124. Sodium Pyrophosphate Corresponding to Whole Meal. Started April 27, 1911.

Our cottonseed meal contained 1.76 per cent of P_2O_5. If it were all in the form of pyrophosphate, 0.4157 grams of sodium pyrophosphate containing 0.222 grams of P_2O_5 would contain an amount equivalent to 12.5 grams of meal.

Four rabbits varying from 790 to 1550 grams, average 1117 grams, were fed daily 0.4157 grams $Na_4P_2O_7$. Each animal gained in weight, the average gain being 243 grams. At the end of 52 days the feed was discontinued, all the animals being in good condition. For each kilo of animal the equivalent of the feed in cottonseed meal was total 582 grams, daily 11.2 grams.

This feed furnished each animal daily with more pyrophosphoric acid than the amount received by each animal eating the raw meal, yet this feed was non-toxic and the meal toxic. This indicates that pyrophosphoric acid is not the cause of toxicity in cottonseed meal.

Our next step was to ascertain which was the more toxic portion of the meal, the aqueous extract, the pepsin-pancreatin extract of the residue undissolved by water, or the residue undissolved after both of these treatments.

For the purpose we prepared feeds Nos. 170, 171, and 172.

Feed No. 170. Aqueous Extract Cottonseed Meal. Started October 23, 1911.

1260 grams of cottonseed meal were stirred at room temperature with 1050 c.c. water and 10 c.c. chloroform for 24 hours. The solution was filtered, the liquid evaporated over a waterbath to a syrup, poured over 240 grams of bran, mixed thoroughly, dried, and fed to each animal in amounts corresponding to 30 grams of cottonseed meal daily—twice our normal feed. Six animals were taken. One animal died after 16 days, having lost 369 grams. The death being from causes other than the feed the observations are not included. The other five animals ranged in weight from 1137 to 1947 grams, average 1400. The feed was discontinued after 38 days, the animals having gained an average of 203 grams. There were 2.26 grams of P_2O_5 in the total average feed, or 0.06 grams in the daily feed.

Feed No. 171. Pepsin and Parcreatin Extract. Started October 23, 1911.

The residue left upon the filter in preparing Feed No. 170 was washed thoroughly with hot water and then digested at 40 degrees for one day each with pepsin and pancreatin. The mass was filtered, the filtrate evaporated over a waterbath to a syrup, poured over bran and dried. Each animal was fed daily the amount corresponding to 30 grams of cottonseed meal—double our normal.

Six rabbits were taken, ranging in weight from 1516 to 1864 grams, average 1683. At the end of 38 days the feed was discontinued, the animals having gained an average of 73 grams each.

There were 5.22 grams of P_2O_5 in the total feed or 0.14 grams in the daily feed.

Feed No. 172. Residue Undissolved by Treatment With Water, Pepsin and Pancreatin. Started October 23, 1911.

The mass left after filtering off the solution from which feed No. 171 was prepared was washed with hot water and dried. It was then finely ground in a mill. 8.8 grams corresponding to 15 grams of meal were mixed with bran and molasses and fed to each of six rabbits. The rabbits ranged in weight from 1374 to 1773 grams, average 1592 grams. Five died in 14 to 16 days, and the remaining one died at the end of 27 days—the average of all being 18 days. The average loss in weight was 325 grams. The total feed consumed corresponded to cottonseed meal equivalent to 116 grams per kilo initial average weight of animal, the average for a day being 6.4 grams per kilo. The total P_2O_5 consumed by the average was 1.96 grams, the average for a day being 0.11 grams P_2O_5.

It is thus seen that the residue undissolved by the treatment of the meal with water, pepsin and pancreatin solution, is toxic but both of the extracts, although they corresponded to almost three or four times as much meal, were non-toxic.

The total P_2O_5 in the toxic portion (1.96 grams) was less than in either of the non-toxic fractions.

Feed No. 122. Residue Undissolved by Pepsin and Pancreatin. Started May 4, 1911.

Cottonseed meal was digested as for feed No. 67 with pepsin and pancreatin. The mass was filtered and the residue was washed with water, dried, and ground. 10.7 grams corresponded to 15 grams of meal. Three rabbits were taken, weighing 1860 and 2284 grams, average 2123 grams. All lost in weight, the average being 552 grams, and all died in an average of 21 days—the range being from 15 to 27 days. The total feed per kilo of animal corresponded to an equivalent of 128 grams of cottonseed meal, the average daily feed being 6.1 grams per kilo. There were in the total average feed 1.40 grams P_2O_5, making a daily average of 0.07 grams.

This feed resembled closely feed No. 172, both in composition and results and confirms our conclusions that the most toxic part of the meal is in the residue undissolved by pepsin and pancreatin.

We next prepared a feed which had an inappreciable amount of P_2O_5 and yet which was toxic. Our solvent was ammonium citrate solution.

Feed No. 123. Residue After Citrate Extraction. Started April 28, 1911.

450 grams of cottonseed meal were extracted with 1500 c.c. of a solution of ammonium citrate following theA.O.A.C. method for determining insoluble phosphoric acid. The mass was filtered, the residue washed and dried. 7.8 grams were the equivalent of 15 grams of meal.

Four rabbits were placed on the feed April 28, 1911, and one on it on May 21, 1911. The weights ranged from 1350 grams to 2380, average 1602 grams. All lost in weight, the average loss being 438 grams. All died in from 17 to 29 days, the average being 21 days. The total feed-equivalent in cottonseed meal was 168 grams and the daily feed 8.0 grams per kilo of initial live weight.

The total P_2O_5 consumed by each was 0.60 grams, a daily average of 0.03 grams. This feed was almost as toxic as the whole meal or the pepsin pancreatin residue, although it contained but an insignificant amount of P_2O_5.

Feed No. 182. Sodium Pyrophosphate. Started January 17, 1912.

Twenty-one days of our feed No. 123 (the residue after ammonium citrate extraction), contained a total of 0.60 grams of P_2O_5. If all the P_2O_5 were in the form of pyrophosphate it would be the equivalent of 1.11 grams of $Na_4P_2O_7$. This amount dissolved in 60 c.c. distilled water was fed on January 17, 1912, at one feeding, through a catheter to each of six rabbits, whose average weight was 1827 grams. The weights ranged from 1732 to 2037 grams. The average gain for each animal was three grams. The animals did not seem to experience any ill effects from the feed.

As the citrate residue (feed No. 123) which proved toxic in 21 days contained a total of 0.60 grams of P_2O_5, and as this amount of P_2O_5 in the form of $Na_4P_2O_7$ given at a single feeding to each of six rabbits (feed No. 182) proved harmless, the cause of the toxicity of the citrate residue is not pyrophosphoric acid.

SUMMARY.

Feeds Nos. 67 and 73 show that the pepsin pancreatin extract of cotton seed meal is toxic generally to rabbits, when fed in amounts corresponding to from 15 to 20 times the amount of meal normally fed, and that the pyrophosphoric acid corresponding to this extract is toxic if fed similarly.

Feed No. 120 shows the toxicity of our meal towards our rabbits.

Feeds Nos. 170, 171, and 172 show that the pepsin pancreatin residue is more toxic than the aqueous or pepsin pancreatin extracts of the meal, in fact that it is the only one of the three fractions which is toxic under the conditions of the feeding. Feed No. 122 confirms this conclusion as to the toxicity of the residue.

Feeds Nos. 123 and 182 show that a fraction of cottonseed meal containing a non-toxic amount of pyrophosphoric acid, is toxic.

These feeds considered together indicate that pyrophosphoric acid is not the cause of toxicity of cottonseed meal.

These results are shown in the following table:

Feed	No. of Feed	No. of Animals	Weight of Animals (Grams)		Days Fed	C. S. M. Equivalent Gms. Per Kilo		Grams of P_2O_5 Fed		Fatal?
			Initial	Gain or Loss		Total	Daily	Total	Daily	
P. & P. extr.	67	9	1752	—123	1	114	114.0	2.22	2.22	yes to 5; no to 4
$Na_4P_2O_7$	73	2	1763	--------	1	113	113.0	2.22	2.22	yes
Raw meal	120	12	1559	—379	13	100	7.7	2.76	0.21	yes
$Na_4P_2O_7$	124	4	1117	243	52	582	11.2	11.52	0.22	no
Aq. extr.	170	5	1400	203	38	794	23.7	2.26	0.06	no
P. & P. extr.	171	6	1683	73	38	677	17.8	5.22	0.14	no
Res. A., P. & P.	172	6	1592	—325	18	116	6.4	1.96	0.11	yes
Res. P. & P.	122	3	2123	—552	21	128	6.1	1.40	0.07	yes
Citrate res.	123	5	1602	—438	21	168	8.0	0.60	0.03	yes
$Na_4P_2O_7$	182	6	1827	3	1	148	148.0	0.60	0.60	no

FEEDING AND TOXICITY OF COTTONSEED MEAL.

By R. S. Curtis.

The feeding of cottonseed products to live stock had its beginning about the close of the Civil War, when conditions were such that the farmers who owned live stock were compelled to take advantage of every possible available foodstuff to tide over the emergency. Prior to this time it had not entered the minds of many stockmen that cottonseed products could be used for stock feeding purposes. They occupied the same place as a by-product as did the viscera of slaughtered animals prior to the advent of the modern abattoir. Cottonseed and their products were considered so worthless that they were dumped in the streams nearest to the gin house. The hog more than any other animal is responsible for the discovery that cottonseed was fit for animal food, and that it does contain a constant yet varying toxic property. While the writer is unable to say definitely whether cottonseed products are more fatal to swine than to other domestic animals, suffice it to say that the losses from this source have always been more apparent. Losses by death upon beef cattle, dairy cattle, horses and sheep are reduced almost to nullity compared with the losses from swine, both in practical and experimental feeding. Whether this is due to a greater constitutional immunity on the part of the animals above mentioned, or whether it is due to the peculiar structure of their stomach and alimentary tract (except the horse) the writer is unable to say. However, such is the case and while it is possible to establish a safe and practical method of feeding cottonseed products to beef and dairy cattle, sheep and horses, the writer hesitates to make the statement that the meal will ever enter into general commercial use as a swine feed. Under the watchful eye of an experienced stockman, cottonseed meal can be used with some profit, but for the average farmer it is not considered wise to advocate its general use in the swine ration. This is true for several reasons: First, swine fed on cottonseed meal may thrive for a time, but later an imperceptible reaction takes place which, if not carefully guarded, may bring the animals suddenly into a condition of unthrift. It has been found that as long as good gains are being made there is no special cause for anticipation of danger, but the average farmer does not have scales to make this determination. Second, the premonitory symptoms of cottonseed meal poisoning are not always as striking and as characteristic as one would suspect from the nature of the trouble. Consequently, death may take place during the night following an apparently normal appetite the evening before. While this is not always true in a number of cases it has occurred during the experimental work on the Station farm, involving the use of a few less than one hundred animals.

One of the most striking cases of the absence of premonitory symptoms was seen in a test to determine the difference in the toxicity of Upland and Sea Island cottonseed meal[1] which Crawford of the United States Department of Agriculture had stated was not toxic except under

[1] This investigation was carried on in coöperation with chemical and veterinary divisions of the station.

certain conditions involving the variety of Sea Island seed and the method of manufacturing the meal from this variety. Two hogs were started on a ration of Sea Island cottonseed meal on May 1, 1911. This ration was continued until the early part of November of the same year, when the conclusion was reached that Crawford was right in his statement, and it was therefore decided to discontinue the feeding of the Sea Island seed on November 24 of the same year. As the initial and final weights of all hogs were taken it was directed that these two hogs be weighed on the above date. An attempt was made to drive them from the small lot wherein they had been fed, but it was noticed shortly that the exercise necessitated in driving them from the pen began to have a marked effect on the equilibrium of the body. The hogs were finally driven from the smaller lot into a larger one where the increased exercise had a still greater effect on the stability of the body movements. One hog finally reached the scale chute and just upon entering lost complete control of the body, fell on the side with an intense rigidity of the body, accompanied by a muscular quivering and jerking motion of the body parts. After a few long gasps for breath life became entirely extinct. The original weight of this pig was 105 pounds, final weight 95 pounds, a loss of 10 pounds, although this condition of the animal would not have been suspected on casual examination. Following this most striking death the second pig was driven on the scales and within a few minutes the same condition became apparent as in the former one. The hog was weighed, driven part way down the scale chute when he also lost body control, and within three to four minutes died in the same manner as the former animal had done. The original weight of this pig was 115 pounds, final weight 145 pounds, showing a gain of 30 pounds in the 208 days feeding period, which should have been ample for a 200 pound gain under normal conditions of feed and management.

This discovery[1] has brought out the striking fact that sudden and violent exercise after close penning does have a marked effect on the fatality of the meal, and also the fact that cottonseed meal, if fed to hogs in a large lot where ample exercise can be taken, will not succumb to its effects as readily as otherwise. Whether this will throw any direct light on the problem is to be determined.

To substantiate the discovery that exercise or lack of exercise does have a marked effect on the toxicity of the meal[1] a third hog which was started on Upland cottonseed meal February 1, 1911, was given the same course of treatment as the two former ones. As this hog was about to be taken from the experiment, the exercising was applied with marked results, although death did not occur immediately. On giving this animal severe exercise it apparently became almost totally blind, and lost entire control of the body. The following description of the symptoms were preserved for record.

For several days previous to death the animal was affected with blind staggers, the eyes being slightly closed and a white exudate coming therefrom. The appetite was practically normal until the last. On approaching the animal the characteristic guttural sound of the swine

[1] This investigation was carried on in coöperation with chemical and veterinary divisions of the station.

family was replaced by a sharp rather ferocious noise characteristic of the female which has just farrowed.

After being released from the small pen (where the feeding had been done) into a half acre lot violent exercise occasioned by running the hog about brought on very unsteady movements and finally complete loss of control, the animal falling on its side and remaining in this condition until equilibrium had partly been restored. Upon rising from the recumbent position the movements were still very unsteady and the vision greatly blurred, as shown by frequent contact with fences and other obstacles. After a time, depending on the amount of exercise given, the animal finally regained almost complete control of the body; however, it was still characterized by deep guttural sounds.

This condition continued for several days, the general symptoms gradually growing worse until death finally occurred on the last day of the month, just one year from the time the feeding started.[1]

The first attempts to feed cottonseed meal to swine in a practical way were characterized by marked and unsatisfactory results. The writer is of the opinion, however, that much of this trouble was due to an attempt to incorporate more cottonseed meal in the ration than was necessary to properly balance it. In fact, in some instances attempts were made to feed the meal as the major part of the ration, which in itself was an unwise plan. Most all of the Southern Experiment Stations have done some work on this problem and in some instances the northern and western stations have done so in an attempt to find a cheaper source of protein to balance the corn rations almost universally used. Practically all of these stations have abandoned the idea, however, and some of them have as a result bent their energies to the solving of the real problem "the cause of the so-called toxic property." The two southern Experiment stations most ardent in recommending the practical use of cottonseed meal in the swine ration are Arkansas and Alabama.

Dinwiddie of the Arkansas Station, in Bulletin 85, recommends feeding it as follows:

Pigs under 50 lbs,	¼ lb. per day.
50-75 lbs.,	⅓ lb. per day.
75-100 lbs.,	4-10 lb. per day.
100-150 lbs.,	½ lb. per day.

While these figures are apparently made on a conservative basis, even these dosages have been known to kill at this and other Experiment Stations, which makes this guide or system recommended not always free from causing deleterious effects. Illustrating this statement, the writer will give a few examples from work carried on at the North Carolina Station.

On November 4, 1908, 16 pigs were started on cottonseed meal rations,[1] the total daily ration aggregating one pound of concentrates for each animal. Of this amount the proportion of cottonseed meal fed ranged from one-fifth of a pound to one-half pound per day. One pig fed cottonseed meal and corn meal in the proportion of 1 to 5 died in

[1] This investigation was carried on in coöperation with chemical and veterinary divisions of the station.

30 days; another on the same ration in 53 days; and still another on the same ration in 63 days. One pig fed cottonseed meal and corn meal in the proportion of 1 to 3 died in 49 days; two more fed on cottonseed meal and corn meal in the proportion of 1 to 2, died in 78 and 88 days respectively. Notice here the contradiction of the Arkansas report where the least amount killed in the shortest time in fact, if the guide given by that station had been reversed it would have applied much better in this case. Still another hog fed cottonseed meal and corn meal in the proportion of 1 to 1 died in 49 days. With this one exception the pigs fed the largest amount of cottonseed meal lived throughout the experiment, and were discontinued on the 91st day in good condition, apparently, at least from all outward indications.

Other experiments at this Station show records of four hogs which have been fed over 300 days on pure cottonseed meal, and with one exception without causing death, and in this case it occurred on the 326th day. One of these four hogs was discontinued on the 414th day, having consumed 637.5 pounds of cottonseed meal, enough to kill six or more hogs under other conditions such as might be caused by a different brand of meal, the individuality of the hogs or their management. This amount of meal would have fattened a 700 pound steer in good condition for market and furnished a more desirable product than the average animal butchered. A number of cases are on record here where hogs have been fed 200 days and over without causing death.

Various treatments have failed to eliminate all or any appreciable part of the toxic property of the meal from a commercial standpoint. Steaming, roasting, boiling, souring, and fermenting have all been tried, but without definite results from a practical viewpoint.

Dinwiddie, of Arkansas, makes the following statement: "The harmful effects of overfeeding with cottonseed meal are manifested in all species of animals so far tested. Hogs exhibit no great excess of susceptibility over cattle when fed in doses proportionate to their weight." In view of later evidence the writer questions this statement somewhat at least from a practical viewpoint, since we have been unable to substitute cottonseed meal even as a supplement to swine rations with any marked and regular success, while with beef cattle we are able to use cottonseed meal as the sole concentrate and in quantities sufficient to put cattle in a highly finished condition for the buyer of fancy grades of cattle.

NORTH CAROLINA

Agricultural Experiment Station

West Raleigh

C. B. Williams, *Director.*

PRESS BULLETIN No. 24

September 27, 1911.

A Serious Cotton Disease (Anthracnose) and How to Handle It

There is a disease of cotton which is yearly attracting increased attention throughout the cotton belt. It is known as cotton anthracnose.

It is most easily recognized when on the boll, where it forms ulcer-like spots, which, as they age, become pink in the centers. The spot may enlarge so as to affect the whole boll. The diseased part of the boll usually fails to open and often the contents rot. Enquiries from various sections of the State are being received almost daily at the Experiment Station concerning the disease. It has also been especially severe in Alabama and Georgia during recent years, so severe in the latter State that the Legislature has made a large special appropriation for its investigation.

Although the disease is seen and recognized most prominently on the bolls, it also occurs on the leaves and stems. Cotton growers should know that this disease is carried from season to season on the seed, and that seed from a sick boll, even though very slightly diseased, may raise a diseased plant, and this in turn may spread the disease to the whole crop of the next season. There is no satisfactory treatment, and the one point to be remembered is that seed from diseased fields is likely to carry the disease, in fact, almost sure to do so. Even seed from clean fields which has passed through a gin in which diseased cotton has been ginned is dangerous. It is of utmost importance for the grower to be sure that his cotton seed does not come from a field or from a region where this disease prevails.

F. L. Stevens,
Plant Pathologist.

TECHNICAL BULLETIN 8 SEPTEMBER, 1911

NORTH CAROLINA

Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

A SERIOUS LETTUCE DISEASE AND A METHOD OF CONTROL

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

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A SERIOUS LETTUCE DISEASE (SCLEROTINIOSE) AND A METHOD OF CONTROL*

By F. L. Stevens and J. G. Hall.†

PART I.

Lettuce, formerly a garden plant grown for home consumption, has f recent years become an important article of farm production, rep- esenting, says Mr. L. F. Kinney,[1] "a higher form of agriculture ian any known to previous generations." Its production has so in- reased that in 1897 we find the statement that the "sales of this egetable from a single farm during the last fifteen years have mounted to over a half million dollars."

This crop has been grown commercially in the United States for iore than fifty years, and was the first crop to be grown extensively nder glass by market gardeners.[1]

As early as 1872, it was estimated that no less than 50,000 sashes ere used mainly for this purpose within ten miles of Boston.[2]

About 800 acres are now devoted to seed production in California one, making some 400,000 pounds of seed.‡

Lettuce was first grown largely on a commercial scale in Connecticut nd Rhode Island. It was estimated that in 1893 fully nine-tenths f the winter head lettuce sold in New York and other eastern markets as either grown in Rhode Island or in the vicinity of Boston.[3]

During the last decade there has been a large increase in the ship- ent from the South to the metropolitan markets, particularly from orth Carolina and South Carolina where lettuce is grown under oth, and from Florida where it is grown largely in the open. In lorida it was first cultivated under canvas about 1894, Mr. F. D. arner, of Gainesville, and Mr. Denby being among the pioneers in is industry in that State, as was also Mr. J. E. Pace, of Sanford, ho introduced the crop in that place in 1896.

Lettuce is now grown to a large extent in South Carolina, particu- rly at Conway where it was first grown about the year 1900. Charles- n and James Island are other prominent lettuce centers in South arolina.

The Lettuce Industry in North Carolina.

Wilmington was the pioneer lettuce growing community of North arolina, and the first lettuce raised under cloth for shipment in this tate seems to have been grown by D. W. Trask, of Wilmington, about 392, three years before other commercial lettuce was produced in Vilmington. Mr. Trask, who raised lettuce in a small way for the

*The matter here published has in part been presented at various scientific meetings, American Phyto- thological Society, Boston, 1909; the N. C. Academy of Science, Greensboro, May, 1908; the N. C. ademy of Science, Raleigh, May, 1911, and in part published in Bulletin No. 217, N. C. Agr. Exp. Sta.

†Mr. G. W. Wilson has taken the place of Mr. Hall during the last year of the work.

‡Letter from Mr. W. W. Gilbert, Bureau Plant Industry, who gives his information as coming from W. Tracy, Sr., of the Horticultural Office.

home market, had more than could be sold there and was forced ship it. This lettuce sold at from $6.00 to $10.00 a barrel and area under cloth was increased the next year to more than an ac After the third year others began raising this profitable crop, and area gradually increased until it now aggregates between 75 and 1 acres under cloth.

The leading lettuce growers of the Wilmington section are: W. Mills & Sons, F. D. Klein, W. E. Springer, H. L. Thorne, D. Trask, O. Martindale, C. E. Kerr, A. O. McEarchern, B. B. Tra Moses Horne, F. T. Kerr, C. F. Seitter, Add. Hewlett, and Geo. Trask.

Around New Bern lettuce was first grown for market in 1894, by M W. H. Bray with an area of about three acres, and Messrs. Hackbu and Willet with one acre.

Fig. 1.—Lettuce as grown under canvas with irrigation at New Bern, N. C.

The acreage in the immediate vicinity of New Bern, all under cl and irrigated and much of it steam heated, soon increased manyfol The most extensive growers of lettuce around New Bern are or ha been, Hackburn & Willet, W. H. Bray, Edward Clark, J. M. Spenc Thomas Daniels, H. H. Tooker, and J. A. Meadows.

At Fayetteville, commercial lettuce culture was apparently beg about 1895 by Fittzell Brothers with two thousand plants and industry has increased rapidly, the crop at times totalling between and 50 acres.

The principal growers are, or have been, W. H. Tomlinson, J. Pemberton, S. H. Strange, H. T. Drake, J. A. Nicholson, Willi Kyle, W. L. Hawley, Fittzell & Fittzell and many small produce more than forty-five in all.

At Warsaw, about 1897, L. Middleton and J. A. Powell raised l tuce commercially. H. H. Caroton, Will Corbett, O. P. Middlet J. A. Powell, Sr., J. A. Powell, Jr., Henry Middleton, of Warsa and John Hamilton, Charlie Gore, Rob Wells, and Charlie Pickett, of Magnolia, are, or have been, prominent in the industry.

At Maxton, lettuce was grown for shipment in 1902 by H. C. McNair and H. S. McNair.

Considerable lettuce is also grown for shipment at Faison, Willard, Wade, Tarboro, Chadbourn, and Mt. Olive.

Characteristic Symptoms of Sclerotiniose.

Sclerotiniose may readily be distinguished from any other lettuce disease when the specific symptoms are once known.

Of these symptoms the one which first catches the eye of the lettuce grower is the rotting of his plant in whole or in part. When first observed a single leaf may be drooping, or wilting; a day or so later the whole plant appears involved, the outer leaves dropping flat on

Fig. 2.—Plant showing drop, one symptom of sclerotiniose.

the ground, the central head alone remaining standing. At this stage the plant appears as though scalded by an application of hot water. The head also soon succumbs to the rot and topples over. The first conspicuous symptom is this rotting and "dropping" of the whole plant.

Close examination of such rotting plants, especially in the later stages of the disease, reveals the presence of a delicate weft of cotton-like threads on the underside of the affected leaves, especially in the more moist regions as at the base of the leaves near the stem. This character is limited to Sclerotiniose, and is a sure indication of this disease.

FIG. 3.—Sclerotiniose: mycelium growing upon leaves in culture dish. This cotton-like weft of mycelium is definitely characteristic.

In the last stages of the disease, a week or two after the final dropping of the plant, there will be found many small black bodies, varying in size from that of a pin head to a grain of corn, in, or upon, or under the sick portions of the plant. These too are absolutely characteristic of Sclerotiniose.

These three characteristics—the dropping, the cotton-like mycelium, and the sclerotia—if carefully observed, enable anyone to pronounce with certainty as to whether or not a given bed or plant is affected with Sclerotiniose.

HISTORY OF SCLEROTINIOSE IN AMERICA.

The disease characterized by the symptoms indicated above is termed *sclerotiniose* from the fungus *Sclerotinia* which is its cause.

Since one of the chief symptoms of Sclerotiniose, the symptom which certainly first catches the eye of practical lettuce growers, is a dropping ıd rotting of the outer leaves, followed usually by dropping and rotıg of the rest of the plant, this disease has come to be called "the ·op," by lettuce growers in many sections of the country. These mptoms may be produced by several different causes.[4]

"The drop" is therefore not one single definite disease. It is rather condition or a symptom just as lameness of horses is a condition or symptom, not a disease. Lameness may be due to spavin, which is e disease, or to tuberculosis, which is another, etc. So the drop may due to *Sclerotinia,* to *Pythium,* to *Botrytis,* etc., each of these causg a separate disease and each requiring different treatment and ophylaxis according to the nature of its cause.

The first definite knowledge of the existence of lettuce *Sclerotiniose* contained in a communication by Smith in 1900.[4]

The disease is there first clearly and accurately characterized and ributed to its causal fungus, *Sclerotinia libertiana* Fckl. While 00 is thus the earliest date of accurate knowledge concerning this sease, it was in all probability seriously injurious long before that ıe, and many serious lettuce troubles reported from different parts the United States, and attributed to other causes, were doubtless ılly due to Sclerotinia. Sclerotiniose frequently occurs in conjuncn with other lettuce diseases and in many instances inroads upon lettuce beds attributed to *Botrytis, Rhizoctonia, Bacteria,* or other ıses, were probably due in part, even in main, to sclerotiniose, often ıbtless complicated by one or more of these other diseases. Among h early, but somewhat uncertain cases are the following:

Prof. G. E. Stone, of Massachusetts, says in a letter to the senior hor (April, 1908), "I think we have evidence to show that the ease has been here a number of years, and that it is not a native this region. It was doing considerable damage in the lettuce houses the 90's—I think the fungus is not indigenous as it does not occur some of our greenhouses in this State. I know many greenhouses ich became infected with the drop through the introduction of nts from the Boston market-garden district. When I first studied disease I had to introduce it into my greenhouse, and I knew of a nber of houses at that time which never had it.

"I do not believe the disease troubled the very early lettuce growers, l I imagine it was not severe in the 90's. I do not believe the men grew lettuce for 40 or 50 years had much trouble in growing it ler sash or even in their old greenhouses. My predecessor in the ion, Prof. Humphrey, I think probably had the same trouble under ervation when he was here in 1888 or 1889, and probably some of other observers who described the bacterial disease of lettuce, had drop. I have always considered that Sclerotinia and eel worms 'e both introduced organisms, and were not indigenous to our State. at I have said in regard to the sclerotium being absent from some ıses for many years, also applies to eel worms, since there are ıy houses which have never been troubled with these. I look upon ıy of these diseases as simply the result of extensive commercial ıtions with foreign countries."

J. E. Humphrey[5] in 1892 records a lettuce disease in Massachu which Smith[4] thought "covers what is now generally known in lettuce district as 'the drop,'" though there is no real certainty Humphrey had actually to do with sclerotiniose. The only evid that his disease was such is that it occurs in a region where this ease was subsequently very prevalent, and that his description ag with that of the drop.

L. H. Bailey[6] in 1895 pictured a lettuce plant which in the pic appears to be a typical case of drop. He attributed it to *Botrytis,* to *Sclerotinia,* though it is possible that *Sclerotinia* was present an mained unnoticed.

A. D. Selby[7] in 1896 mentioned a disease as "lettuce rot" attribu it to *Botrytis.* This may have been a form of drop, and was pos due in part of *Sclerotinia,* though there is no evidence that anyt but *Botrytis* was present.

G. E. Stone and R. E. Smith[8] in 1897 described a disease w they called "the drop" and which they attributed to *Botrytis.* Th from their later paper it seems possible that this early outbreak in part at least due to *Sclerotinia.*

In 1898 Stone and Smith[9] and again in 1899[10] refer to an outb of lettuce "drop," still attributing it to *Botrytis,* though it prob was in part, even largely, due to *Sclerotinia.*

H. Garman in 1899[11] speaks of lettuce rot, which from his des tion, seems to have been some form of drop. *Botrytis* and othe ganisms were seen, but *Sclerotinia* was not definitely mentioned.

True *sclerotiniose* was mentioned and figured in Hume in 19 He then said "within the last few seasons a disease has wrought siderable destruction to the crop. This disease is commonly k among the growers as 'damp off.' In some cases the attack res in the total loss of the crop, while in others a loss of from 25 t per cent. was suffered."

The disease is said by Rolfs in a letter to one of the autho have been severe in the region of Gainesville about 1896, at w time a number of fields were almost completely destroyed.

Ramsey in 1904[13] described a lettuce disease due to the pre of *Botrytis* on the fall crop and a genuine case of *sclerotiniose* o second crop in later winter. It was clearly characterized by the ence of cottony mycelium and by sclerotia.

In North Carolina, the drop, probably in all cases true scleroti first attracted the attention of lettuce growers around New Be 1897; at Fayetteville in 1901; at Warsaw in 1902. It was ment by the senior author of this bulletin in his Annual Report of 1 and was the subject of a press bulletin in the same year.[15]

It is briefly referred to by Hutt in a bulletin of the North Ca Department of Agriculture.[16]

Sclerotiniose is now known to occur, as is shown in the accom ing map, in all of the South Atlantic States, North Carolina, Carolina, Alabama, Georgia, and Florida, and also in Maine, Ver Massachusetts, New York, Connecticut, Rhode Island, Pennsyl

Delaware, Louisiana, Wisconsin, Washington, and Iowa, and a partially verified record of its occurrence in Virginia exists. While not definitely recorded from other States, it probably occurs in many of them, particularly near the Atlantic seaboard.

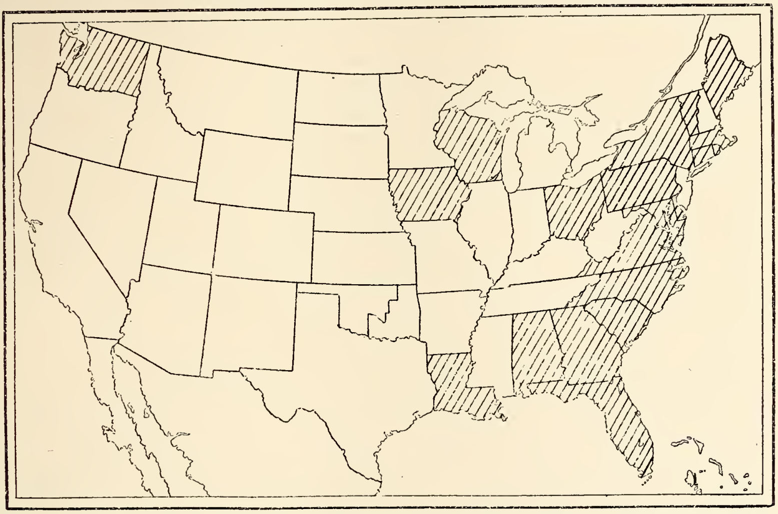


FIG. 4.—Map showing distribution of sclerotiniose in the United States. The disease is definitely reported in shaded States, but is not known to occur in others.

From what is known of the disease it is certain that it persists long and multiplies in territory once infected, and rapidly invades new regions. It is therefore increasing the area under its tribute yearly, and will continue to become of wider significance, especially as the lettuce industry broadens.

Summarizing the history of Scleriotiniose it may be said to have attracted attention first about 1890 in Massachusetts, in 1896 in Florida, in 1897 in North Carolina, in 1904 in Wisconsin, and to now possess practically the whole Atlantic seaboard and some of the more western States.

Amount of Damage.

The extent of the damage varies with the severity of the epidemic and with the value of the crop affected. In 1900 in Massachusetts Stone and Smith[17] placed the proportion of plants succumbing to the disease at 15 to 85 or 95 per cent. of the crop. "The latter percentages are very exceptional, as growers are not content to experience this loss more than once without making radical changes in their methods. Practically entire crops have been destroyed by drop alone to our knowledge, and the majority of growers in Massachusetts have experienced at one time or another a loss of from 15 to 40 per cent. The loss of 25 per cent. from drop is no uncommon experience in a large number of lettuce houses, and when we consider that these houses each may contain from 6,000 to 12,000 plants, worth from 40 cents to $1.00 per dozen, some idea of the loss may be obtained."

In Florida* the loss is very severe and is sometimes complete. In South Carolina while crops are frequently destroyed and the lettuce industry seriously threatened as is shown in the following quotation from a personal letter.† "Several years ago I grew lettuce quite extensively for Northern markets, but had to give it up on account of the damping off. * * * Lettuce is not grown here as extensively as in former years principally on account of this disease."

In Maryland sclerotiniose does damage in many greenhouses.‡

In Alabama sclerotiniose is reported by Wilcox§ to do much damage in those places where lettuce is grown on a large scale. In Auburn and Montgomery it is repeatedly met, with great loss.

In New York, some growers, says Stewart** have had considerable trouble with the drop. It certainly is one of the troublesome diseases of lettuce." Whetzel, of the same State, says "it (the drop) occurs more or less commonly in all greenhouses about this State and sometimes in lettuce fields."

Amount of Damage in North Carolina.

In North Carolina the lettuce "drop" or "damp off" now shows itself to greater or less extent at New Bern, Wilmington, Maxton, Fayetteville, Willard, Raleigh, and probably at numerous localities where lettuce is of less importance. The damage done by it in 1906 is variously estimated at 10 per cent., 20 per cent., 33 per cent., 50 per cent., and 70 per cent. by different growers. At Fayetteville the damage from this disease is estimated at from 10 to 50 per cent. of the total value of the crop. Around Wilmington the loss is placed at 10 per cent. At New Bern estimates vary from 33 1-3 per cent. to 50 per cent., while at Maxton the loss is placed at 20 per cent.

The disease sometimes appears the first season the crop is grown in a given soil, often not until many crops have been raised. When once it does gain a foothold in a bed it persists, multiplies and increases until usually the grower is forced to move the bed to new regions, usually to very soon meet again a similar fate. Thus the loss to the crop is coupled with the loss attendant upon moving the lettuce bed, frames, irrigating, and heating pipes to new land and the leaving of the enriched soil to go to a newer and poorer one.

Cursory Description of Sclerotiniose.

The cause of the "drop" is a fungus belonging to the genus *Sclerotinia,* a genus which is well known on account of its many destructive species, among them being two that are particularly conspicuous, one causing a serious and widespread apple rot and the other causing one of the worst of peach diseases. The fungus is known technically as *Sclerotinia libertiana Fuckel.* It was first described in 1869, and bears its present name, libertiana, in honor of Marie Anne Libert

*Letter from P. H. Rolfs, March 30, 1908.
†D. T. West, Charleston, S. C., May, 1907.
‡Personal letter from J. B. S. Norton, December 14, 1906.
§Personal letter from E. M. Wilcox, March 28, 1908.
**F. C. Stewart in personal letter, March 30, 1908.

who published on parasitic fungi from 1813 to 1837. The plant body of this fungus consists of delicate branching, mold-like threads called the mycelium, which may, with the microscope or if abundant with the naked eye, be seen in or on the affected parts of the lettuce plant. No diseased part is free from them and they are, on the other hand, never present without being accompanied by a condition of disease in the adjacent parts of the lettuce plant. It has been definitely proved beyond all peradventure that these fungous threads are the actual cause of the disease and that nothing else can cause this disease.

This fungous mycelium, coming in contact with a lettuce leaf, exudes a poison which kills the near-by cells of the lettuce plant. The cell walls are then dissolved and the mycelium makes its way through or between them. It dissolves also the contents of the cells and absorbs the resulting nutrient solutions to further its own development. The mycelium thus grows larger, kills more cells, consumes them and continues to advance rapidly through the affected leaf until the whole leaf is a soft, slimy, rotten mass. The invasion continues into the main stem, then upward to the central bud and "heart" of the head, out into other leaves, downward through the root until every portion of the host plant has been killed, and the nutritious parts consumed.

Environmental conditions may, to some extent, change the course of the disease. The fungus grows best in abundant moisture. Sometimes this leads to a more rapid decay of the inner protected dry portion of the head, and a plant which to casual inspection appears healthy may prove upon close examination to be, at heart, a slimy, rotten mass. Again through one-sided infection the decay may progress much more rapidly upon one side than upon another, resulting in complete death of one side before the other shows any symptom of disease.

As a rule the mycelium is not visible to the naked eye on leaves until the nutriment within the leaves has been nearly or quite, exhausted by the fungus. When this time is reached the mycelium begins its external appearance as the loose cottony growth referred to above. The most profuse development of this aerial mycelium occurs in the region of more humid atmosphere, such for example as on the under sides of leaves lying upon the ground, between leaves, or at the bases of leaves, in fact anywhere that the air is so situated as to cause it to remain especially humid.

Soon after the appearance of the aerial mycelium in profuse quantity, it may be noted that in each region where the mycelium is dense there appear one or more centers of aggregation, composed of very densely intertangled and interwoven mycelial threads. These denser masses enlarge, increase in density and finally become solid masses of tightly compacted mycelium. These bodies are called *sclerotia*. The sclerotia are at first colorless, then pale salmon color, and finally black on their exterior and flesh colored within. When first formed they are buried in and covered by mycelium, and are only to be seen by tearing this mycelial covering away. As time passes this mycelium is lost, the remains of the lettuce plant disappear, and the only visible evidence of the plant or the fungus then is the sclerotia, many of which are produced in each sick plant.

The sclerotium germinates under suitable conditions, usually after a lapse of several months to nearly a year, under field conditions. This it does by sending forth several thread-like sprouts about one-thirty-second of an inch in thickness. These spiouts expand at the end developing a horn-like or cornucopia-like disk (Fig. 5) called the apothe-

FIG. 5.—Sclerotia-bearing disks; natural size.

cium. This apothecium is, in the field, borne just at the surface of the ground with its face directed upward.

Microscopic examination of the apothecium shows its disks to consist of two parts: (1) lower basal part supporting (2) an upper layer which consists of very numerous small slender tubular bags, or sacs, the *asci*. (Fig. 6.) Each ascus when mature contains eight small

FIG. 6.—Asci and paraphyses in various stages of development.

oval bodies (Fig. 6) the *spores*. It is seen then that the apothecium is essentially an organ whose function is to produce myriads of spores.

When ripe these spores are ejected from the asci by pressure, being forced into the air often to a distance of several feet where, caught

air currents, they may be carried quickly to great distances. The
res under suitable surroundings, germinate and send forth small
ad-like sprouts (Fig. 7). These sprouts, with suitable nourishing
erial, grow rapidly into a vigorous mycelium, which is again ready
nvade the living lettuce plant; to again cause the drop.

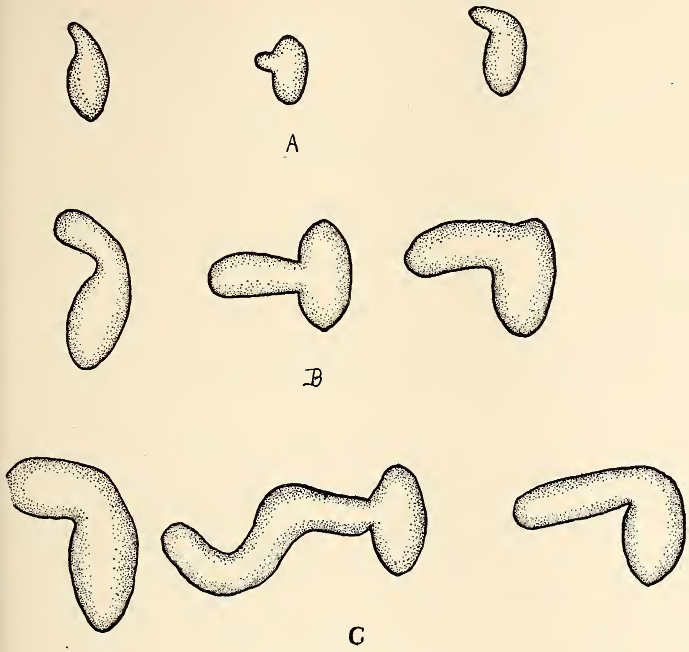


FIG. 7.—Ascospores germinating. *A*. At two hours; *B*, at five hours; *C*, at seven hours.

his history of the drop fungus may be epitomized by saying that
mycelium grows within the lettuce plant, causing the drop; pro-
s sclerotia when nutriment is exhausted; rests in the sclerotial
ition until opportune conditions prevail; the sclerotia then pro-
apothecia bearing asci in which are spores; these spores produce
w mycelium which again invades lettuce plants.

THE FUNGUS THAT CAUSES THE DISEASE.

MORPHOLOGY.

he *mycelium* in gross, as developed external to the leaf in humid
appears as a coarse cottony mass most abundant around the stem
ne plant among the leaf bases. It is also found to a great extent
the lower diseased leaves that lie upon the surface of the ground.
s more plentiful on the under sides of these leaves or between
es if two or more are lying upon each other on the ground, but
seldom makes any extensive showing upon the ground itself un-
under artificial conditions of excessive humidity.

The mycelium is comparatively large and coarse, varying in diam- ter from 5.8 μ to 14.5 μ with many septa (Fig. 8) which divide e mycelial thread into many cells, whose lengths vary with their posit

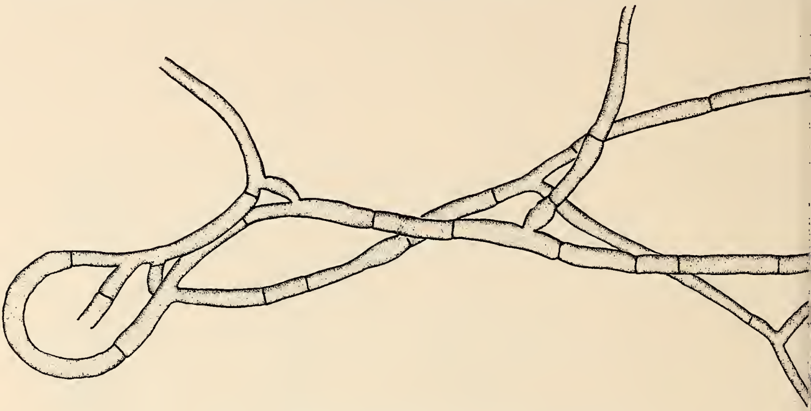


FIG. 8.—Mycelium showing septation and branching.

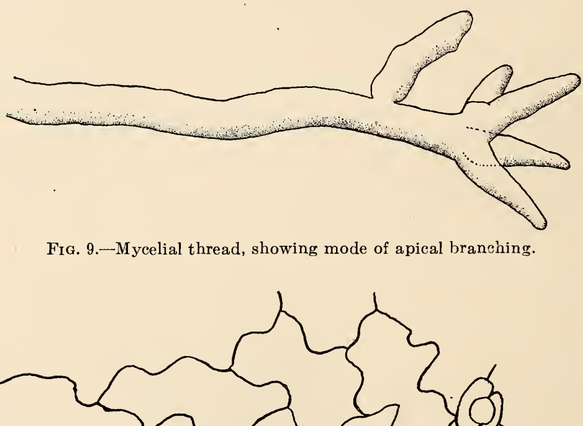


FIG. 9.—Mycelial thread, showing mode of apical branching.

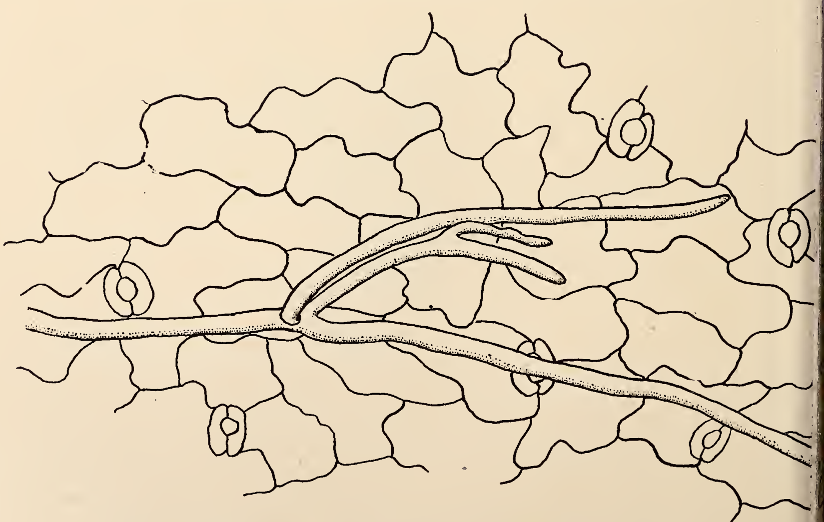


FIG. 10.—Lettuce leaf, showing stomata and superficial sclerotinia mycelium.

in the hypha. In the younger growing tips the septa are very far apart, and become closer in the older parts. There is no completely regular method of hyphal branching, although the greater number of

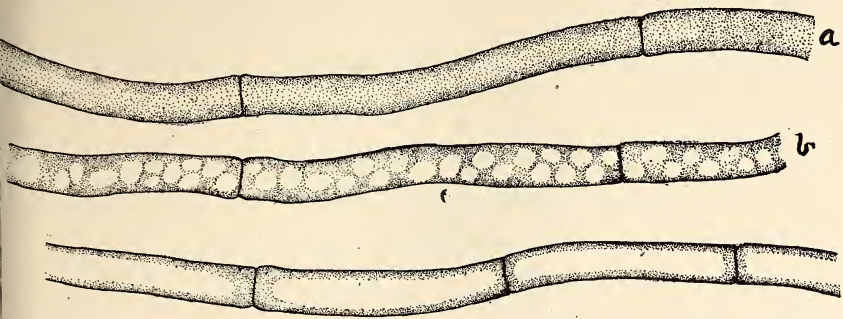


FIG. 11.—Mycelial thread showing three stages in its development; *a*, young; *b*, medium; *c*, old.

branches seems to arise as perpendicular outgrowths near the end or middle of a cell, Fig. 8. There are two other methods of branching, one of which will be discussed under "attachments." The other is

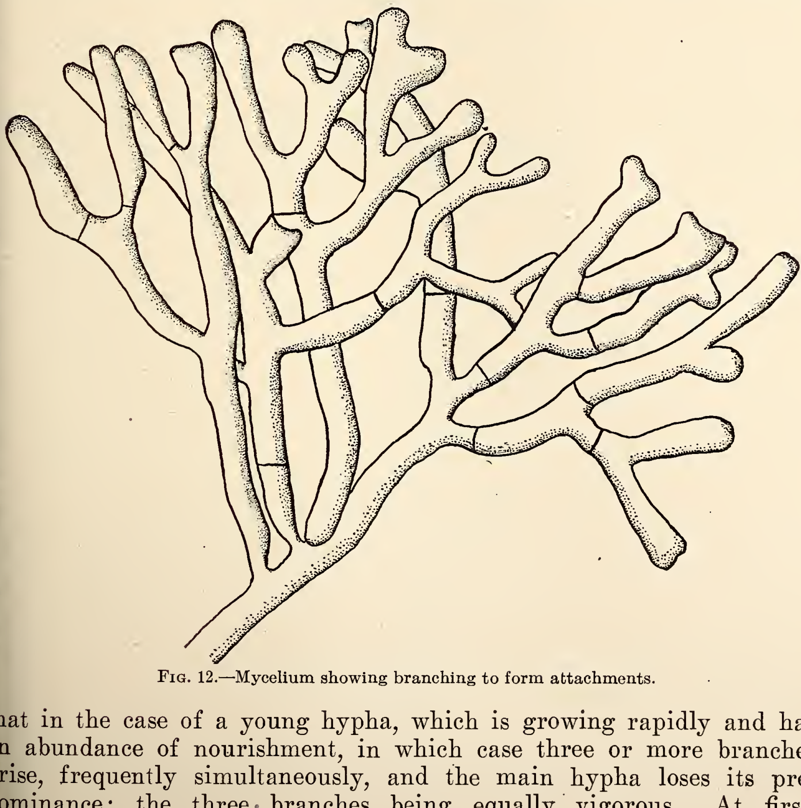


FIG. 12.—Mycelium showing branching to form attachments.

that in the case of a young hypha, which is growing rapidly and has an abundance of nourishment, in which case three or more branches arise, frequently simultaneously, and the main hypha loses its predominance; the three branches being equally vigorous. At first,

2

as in the youngest mycelium, the contents of each thread is a more or less homogenous mass, Fig. 11a, of protoplasm, but gradually as the hypha grows, there appears first a single row of vacuoles,

FIG. 13.—Portion of attachment organ showing flattening of the tips.

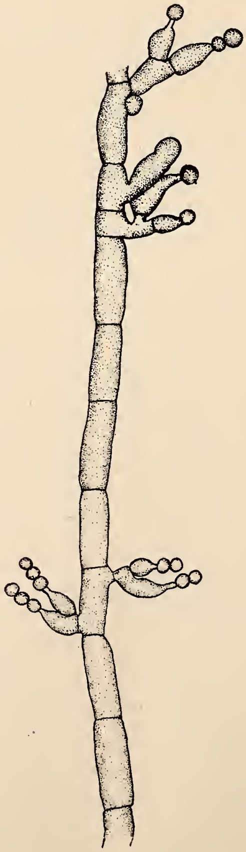


FIG. 14.—Mycelium showing method of production of gonidia.

Fig. 11b. These increase until the whole filament becomes very vacuolate, and finally all apparently coalesce to one large vacuole which nearly fills the whole of the cell, Fig. 11c.

The *attachments* first appear as numerous short branches from near the tip of an ordinary hypha. Each one of these primary off-shoots produces branches that again branch forming a rather compact mass, Fig. 12. They are at first continuous but very soon become septate.

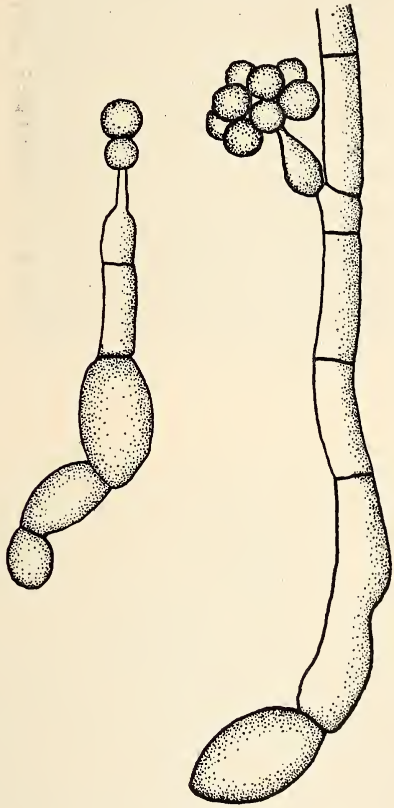


FIG. 15.—Germ tubes from ascospores producing gonidia.

With the appearance of the septa the tips of the branches enlarge. When they come into contact with some solid as a culture dish or a lettuce leaf, they become somewhat flattened, Fig. 13, on the end and apply themselves to and cohert to the substance.

Gonidia.—Frequently both in drop and in plate cultures there are found small spherical bodies, *gonidia,* that appear very much like spores, Fig. 14, although they have never been seen to germinate. They are highly refractive bodies, measuring about 2 to 3 mu in diameter, and are produced in large numbers in acropetal succession upon flask-shaped stalks. These stalks are produced either as lateral branches of an ordinary vegetative hypha or as the termination of such hypha. They are at times also produced in abundance upon the germ tubes formed by the ascospore, Fig. 15. In some cases several are formed close together, so that many gonidia are produced together, forming a large mass and completely hiding the stalks that bear them.

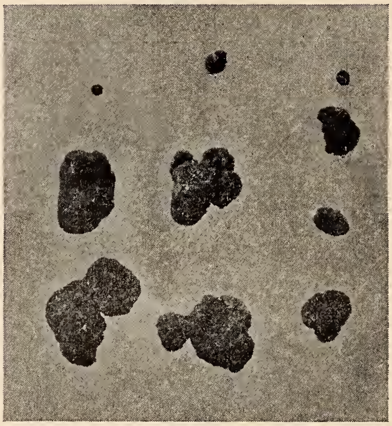


Fig. 16.—Sclerotia taken from one infected plant, showing variation in size.

Sclerotia.—Upon suitable media in the laboratory and upon plants in the field the purplish black resting bodies, the sclerotia, are formed. These vary much in shape, some of the smaller ones being almost

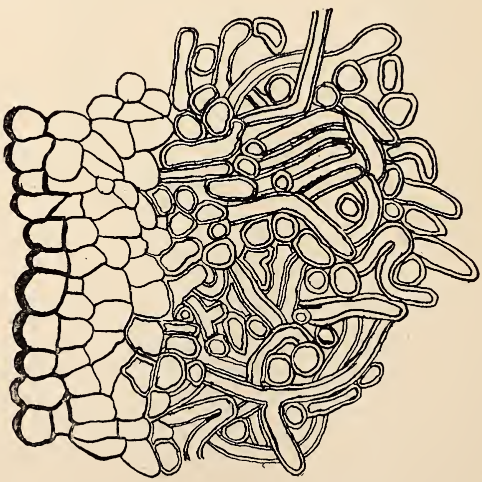


Fig. 17.—Section of a sclerotium showing parenchyma-like rind and modified mycelium of the interior.

spherical and some of the larger ones long, irregularly cylindrical or flat. In size there is also much variation, the smallest ones being no larger than a pin head, while the larger ones are larger than a grain of corn. The large and the small are however in nature and in normal cultures, produced indiscriminately together, and in no case was there a production of either large or small ones exclusively.

When first gathered from the field their average weight was determined as .06 grams each. After dying in the laboratory for a year they averaged .02 grams as determined upon a weighed hundred. They are somewhat rough on the surface and have a rather tough exterior protecting layer composed of two or three layers of parenchyma-like cells with thick, hard, black walls, Fig. 17. Internally the sclerotium consists of a compacted mass of mycelial threads, which do not vary perceptibly from the ordinary mycelium, except that they have much thicker walls and narrower lumen, Fig. 17, and their diameter is less than that of the vegetative hyphæ.

In cultures in the laboratory it was possible to follow the development of the sclerotia accurately. At first there occurs a massing of the mycelium, causing a white, somewhat raised bunch of mycelial threads, floccose in appearance. These masses as they grow, exude numerous small drops of a colorless watery liquid, after which they change to cream color, which gradually passes to a dirty yellow, the developing sclerotial membrane losing their floccose character. Their color changes to a greenish black, afterward to almost pure black as they mature.

FIG. 18.—Sclerotium with disks. *a*, Photographed January 10; *b*, January 12; *c*, January 14. Note the recurved edges of the largest disk.

To secure *germination of the sclerotia,* they were placed in moist sand in flower pots which were kept standing in a pan of water thus keeping the sand wet by capillarity. After about two months the sclerotia began to send out minute yellowish-brown bud-like protuberances. These rapidly elongated to form a filament which as soon as it reached above the soil and into the light, began to expand, at first to an urn-shape and then gradually flattening into a broad, flat disk, Fig. 18. In some cases the disk became recurved with age, Fig. 17c, having the appearance of a very minute yellowish brown umbrella, the ascophore. From 3 to 35 ascophores were produced from each sclerotium.

The Ascophore.—The *Ascophore* may be regarded as composed of two portions, the stalk or stipe, and the disk, though no sharp line of demarkation can be drawn between these parts. As many as thirty-five stipes have been noted from a single sclerotium, but usually there are not more than eight or ten. There are no particular points upon the sclerotium from which they arise, but in case the sclerotium lies upon the surface of the ground, they usually spring from the sides of it nearest to the soil. Their length depends upon the depth of the sclerotium in the soil. If the sclerotium is upon the soil surface, the stipe is just long enough to allow the disk to expand. When the sclerotium is buried the stipe becomes a sufficient length to reach the surface, sometimes attaining a length of 3 to 5 cm. In thickness the stipes vary from about 0.5 to 1.2 mm. The color of the shorter stipes is almost universally brownish yellow, but the longer ones while brownish yellow just below the disk are dark brown to almost black at the sclerotial end.

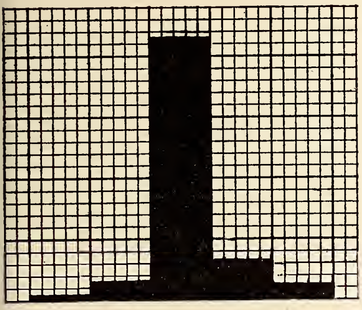
In cross section the stipe is seen to be hollow and to possess an outer cortical region composed of two or three irregular layers of black thick-walled cells, encasing a tissue of parenchymatous appear-ance. In longitudinal section, cells of the outer cortical layers appear about three times as long as wide, while the rest of the tissue appears as a mass of ordinary mycelial threads with rather more than the usual number of septa.

The disk is borne upon the end of the stipe. It is at first very small and deeply cup shaped. This cup gradually expands at the rate of one-half to 1 mm. per day and forms the flat or concave circular disk, which sometimes attains a diameter of 16 mm. It is composed of two distinct parts, the *stroma* and the *hymenium.* The stroma or basal part consists of a mass of closely interwoven hyphæ with an outer cortical parenchymatous layer two or three cells thick which forms the under surface of the disk. The stroma supports the hymenium composed of *asci* (Fig. 6) and *sterile* hyphæ lying between them, the paraphyses (Fig. 6). The asci are cylindrical with a gradually narrowing base. They measure about 82 x 2 mu and bear 8 spores in their distal half. The asci are very numerous, there being about 30,000 in a single disk of usual size. Between the asci and more numerous than the asci are the very fine thread-like paraphyses which are slightly longer than the asci, and not more than one-third as thick. The paraphyses do not differ materially from the ordinary hyphæ of the mycellium.

The spores found in the asci are hyaline, oblong, elliptical with somewhat pointed ends, and when mature bear two vacuoles. They measure 5.8 x 8.7-11.6 mu.

In a single disk there are about thirty-one million spores; in a single sclerotium of average size about three hundred and ten million spores. Allowing a fair number of sclerotia to each diseased lettuce plant it is seen that it can produce as many as five billion spores.

When mature the spores are ejected forcibly from the asci. Great numbers of them ripen at the same time and the slightest change in environmental conditions, as a slight draught produced by the breath causes myriads of them to be thrown into the air often to a distance of 0.5 to 1.0 meter, their great number rendering them visible as a steam-like cloud which, caught by air currents, can often be followed by the eye to a distance of several meters.

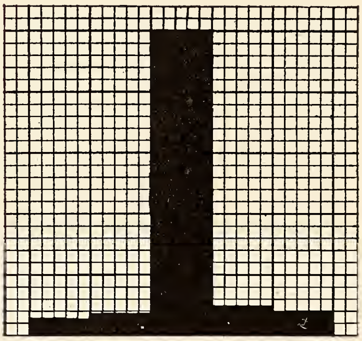


3 3.5 4 4.5 5

FIG. 19.—*Sclerotinia libertiana* Fckl. Polygon of ascospores from middle-aged disk.

$$M = 4.0880 \pm 0.0166$$
$$\sigma = 0.2930 \pm 0.0117$$
$$C. V. = 7.168 \pm 0.290$$
$$n = 142$$

$$M = 4.0393 \pm 0.0214$$
$$\sigma = 0.3743 \pm 0.0151$$
$$C. V. = 9.267 \pm 0.380$$
$$n = 165$$



3 3.5 4 4.5 5

FIG. 20.—*Sclerotinia libertiana* Fckl. Polygon of spores from young disk.

Several hundred measurements were made from disks of various ages to determine the normal variation in sizes of ascospores with the results shown in Figs. 19 and 20.

It is seen that the spores are remarkably constant in size and that the age of the disk (Figs. 19 and 20) from which they are taken has no material effect upon their measurements.

The spores as discharged from the asci are ready, if they fall in favorable places, to germinate at once. In germination they first enlarge somewhat and soon a protuberance can be seen at some spot on the surface. This protuberance increases in length, becomes septate and constitutes the germ tube, the beginning of the mycelium.

The Species of the Fungus.

The species under consideration has by recent writers been regarded as *Sclerotinia libertiana* Fuckel which is thus described[19]:

"Sparsa, stipitata, nuda, pallida, cyathoidea, 4-8 m.m. lat.; stipite tenui subflexuoso, *Sclerotio* tuberiformi, nigro innato, plus minus elongato, sæpissime 3 cm. long; ascis cylindraceis, 130-135 x 8-10, apice jodo dilute coerulescentibus; sporidiis monostichis, ellipsoideis, vulgo minute guttulatis, 9-13 x 4-6.5; paraphysibus parcis, clavulatis."

Comparison of the fungus under discussion with the description of eleven species which most nearly agreed with it showed that all failed to agree with it in some important point except *Sclerotinia libertiana* and *S. kauffmanniana;* the latter considered a synonym of *S. libertiana* by some authors.

Physiology.

The Mycelium.

Media.—This fungus lends itself readily to culture upon either artificial or live media. Its growth upon various media was first studied to ascertain the best medium to employ in experimental work and the best medium for stock cultures.

Upon lettuce leaves in culture dishes a great mass of mycelium of loose cottony consistence, which very quickly collapsed on exposure to the air, was produced and very few sclerotia were formed.

In lettuce broth a vigorous mycelium developed.

Lettuce agar gave only a very thin surface layer of mycelium, and very few sclerotia.

Four-per-cent. pea-agar gave about the same growth as did lettuce agar.

Sterilized corn meal, wet with apple juice, gave excellent growth and produced by far the greatest number of sclerotia. The mycelium while mainly coating the surface of this medium was very compact and dense. Corn meal wet with lettuce broth was equally satisfactory. In all of the foregoing media a much more abundant mycelium was formed if the medium was slightly acid.

The corn-meal-apple-juice mixture was adopted for the study of the development of sclerotia and as a medium on which to maintain stock cultures. Lettuce broth was used to grow mycelium for tests regarding the effects of soluble chemicals, since the mycelium developed well, and uniformly, in this medium and was readily wetted by the solutions employed in the experiments which was not the case when media leading to the development of a profuse aereal mycelium were employed.

Experiment 9, Inoculated 11-30-1906. To determine the *temperature relations* of the fungus.

Sclerotinia libertiana was grown upon lettuce agar, acidity +.55 Fuller's scale, and upon lettuce leaves at cool, room temperature, incubator temperature and in an open shaded window, all in ordinary diffused light except the culture in the incubator room which were in the dark. The results are shown in the following table.

TABLE I.—SHOWING RELATION OF TEMPERATURE TO GROWTH.
FIGURES INDICATE TOTAL GROWTH RECORDED AS MILLIMETERS.

Medium	Condition	Growth										
		December										
		1st	3d	4th	5th	6th	7th	8th	10th	11th	12th	13th
Agar	Window shaded	1	5	5	5	10	15	17	23	30	35	37
Lettuce leaf	Window shaded	0	0	5	5	25	30	40	60	60	70	70
Agar	Cool room	4	13	20	40	40	47	53	70	70	78	------
Lettuce leaf	Cool room	20	20	20	35	50	------	------	------	------	------	------
Agar	Incubator room	4	6	6	6	6	6	6	6	6	6	------
Lettuce leaf	Incubator room	4	4	4	------	------	------	------	------	------	------	------

It is clearly evident that the incubator temperature (approximately 37 1-2 degrees) was unfavorable to the growth of the fungus. Growth stopped entirely after the first few millimeters and was not resumed, nor were any sclerotia formed.

The room temperature, which was considerably warmer than the window temperature of December, was more favorable to growth, resulting in complete occupancy of the plate in 9 to 11 days. While growth was slower at the colder outdoor temperature it still continued vigorously and normally, leading eventually to complete occupancy of the plate. Sclerotia were formed upon the lettuce leaf at both room and outdoor temperatures.

Experiment 48, March 12, 1908. To determine more accurately the optimum growth temperature in agar, cultures were made in this medium and placed in an optimum temperature apparatus.*

The work was done in quadruplicate and care was taken to have all cultures as nearly as possible parallel as to moisture, quantity and quality of inoculum and all factors except temperature. The results are expressed in table II.

It is seen that growth was markedly less in the two warmer compartments (29 and 36-39 degrees). No growth at all occurred in the warmest compartment and no sclerotia formed in either of these compartments. In the compartment of lowest temperature (13-18 degrees) growth was also much retarded but it still continued, leading to complete occupancy of the plate in twelve days and to sclerotial formation in thirteen days.

*An incubator with six compartments, giving a considerable range of temperatures.

TABLE II—SHOWING RELATION OF TEMPERATURE AND GROWTH.

	Temperature—Compartment Number								‡ Growth—Compartment Number					
	1		2	3	4	5	6		1	2	3	4	5	6
Date	Max.	Min.					Max.	Min.						
3-14-08	13	16	21	24	26	29	36	39	0	4	5	3	4	0
3-16-08	13	21	23	25	27	29	36	39	10-15	16-21	20	17	16	0
3-17-08	13	23	21	24	26	29	36	39	0-10	13-15	13	10-15	7	0
3-18-03	13	17	21	24	26	29	36	39	5-10	13-16	14-17	0- 5	8	0
3-19-08	14	17	21	24	26	29	36	39	7-27	13-21	5- 9	2	5	0
3-20-08	13	16	21	24	26	29	36	39	8-25	F*	F	8	5	0
3-21-08	14	17	21	24	26	29	36	39	5-10	F	F	10	5	0
3-23-08	13	18	21	24	26	29	36	39	10	F	F	10	10	0
3-24-08	13	16	21	24	26	29	36	39	10-25	F	F	F	0	0
3-25-08	12	18	21	24	26	29	37	39	F	S†	S	S	0	0
3-26-08	13	18	21	24	26	29	36	39	S	S	S	S	0	0
Average number of sclerotia per culture									1	2	2	1.8	0	0

* F indicates date upon which mycelium filled plate.

† S indicates that sclerotia were forming.

‡ Growth for each day is recorded in millimeters. In compartments 1 and 6 maximum and minimum thermometers were used.

Of the four compartments of intermediate temperature the two cooler (21 and 24 degrees) were more favorable than the two warmer (26 and 29 degrees). In the two former complete occupancy of the plate by the mycelium occurred in six days while the others required four days more.

From these tests we may conclude that this fungus can not continue to grow long at a temperature of 29 degrees or higher; that at a temperature as low as 13-18 degrees or as high as 26 degrees growth proceeds normally but not so rapidly as at the optimum temperature; which lies between 21 and 24 degrees.

Experiment 13. To determine *longevity of mycelium* in agar in petri dishes. A ten-per-cent. lettuce agar was employed, acidity +.55 Fuller's scale. Tests were made in the laboratory, the results of which appear in table III.

From this table it is seen that the mycelium remained alive as long as forty-eight days, but in no case did it live beyond the fifty-fifth day. The length of life after the agar was dry in the petri dish varied from five to ten days.

Experiment 12. To determine the *effects of various nutrients* upon growth. Sclerotinia was grown in petri dishes upon plain agar with various nutrients added. 10 c.c. of medium was used in each dish. The petri dishes were inoculated 12-11-1906.

TABLE III.—SHOWING LONGEVITY OF MYCELIUM IN AGAR IN PETRI DISHES.

late No.	Date of Inoc.	Date of Filling Plate	Date of Drying	tested	alive	tested	alive	tested	alive	tested	alive	tested	alive	tested	alive
1	5-15-09	5-21	6-20	6-1	Yes	6-14	Yes	6-23	Yes	6-30	Yes	7- 7	No	------	------
2	5-15-09	5-21	6-20	6-1	"	6- 8	"	6-14	"	6-23	"	6-30	Yes	7- 7	No
3	5-15-09	5-23	6-22	6-1	"	6- 8	"	6-14	"	6-23	"	6-30	"	7- 7	No
1	6-14-09	6-18	7-18	6-18	"	7- 7	"	7-14	"	7-23	"	8- 3	No	------	------
2	6-14-09	6-18	7-18	6-18	"	7- 7	"	7-14	"	7-23	"	8- 3	"	------	------
3	6-14-09	6-18	7-18	6-18	"	7- 7	"	7-14	"	7-23	"	8- 3	"	------	------
4	6-14-09	6-18	7-18	6-18	"	7- 7	"	7-14	"	7-23	"	8- 3	"	------	------
1	9-23-09	9-27	10-28	9-30	"	10-14	"	10-28	"	11- 7	"	11-10	"	------	------
2	9-23-09	9-27	10-28	9-30	"	10-14	"	10-28	"	11- 3	"	11-10	"	------	------
3	9-23-09	9-27	10-28	9-30	"	10-14	"	10-28	"	11- 3	"	11-10	"	------	------

As might have been expected growth was very slow in plain agar, while 5 per cent. glucose, and 1 per cent. starch proved most favorable. Lettuce agar was much superior to plain agar but far less nutritious than starch or glucose agars.

The deficiency of the peptone and lactose agars is striking, seeming to emphasize the lack of need of rich nitrogenous foods for this fungus and to show the superior value of glucose over lactose as a source of carbon. There was no reddening of the litmus lactose agar by the mycelium.

Sclerotia were formed on all of these media except the peptone and the litmus lactose agar.

TABLE IV.—SHOWING EFFECTS OF VARIOUS NUTRIENTS UPON GROWTH.

GROWTH IS RECORDED IN MILLIMETERS.

	Medium	Days									
		1	2	3	4	5	6	7	8	9	10
1	Plain agar	5	9	14	20	23	25	30	30	39	---
2	Plain agar	2	2	12	16	25	32	35	36	43	---
3	Plain agar+1 per cent glucose	3	11	25	28	34	38	42	----	----	---
4	Plain agar+1 per cent glucose	1	4	10	10	15	24	26	----	----	---
5	Plain agar+5 per cent glucose	2	8	40	65	----	----	----	----	----	---
6	Plain agar+5 per cent glucose	3	25	75	Fills Plate	----	----	----	----	----	---
7	Plain agar +1 per cent peptone	2	5	10	10	12	12	15	----	----	---
9	Plain agar+Litmus lactose	2	10	20	24	26	28	----	----	----	---
10	1 per cent starch agar	3	13	30	40	45	50	60	----	----	---
11	1 per cent starch agar	2	8	25	42	----	50	58	----	----	---
12	Lettuce agar	4	13	20	40	47	53	70	----	----	---
13	Lettuce agar	4	8	14	22	32	42	48	----	----	---

Experiment 8. To determine the *influence of acidity or alkalinity* of the medium. On December 8, 1906, the fungus was inoculated and grown in lettuce agar of various degrees of acidity and alkalinity as is shown in the table following.

TABLE V—SHOWING RELATION OF ACIDITY TO GROWTH.

TOTAL GROWTH IS RECORDED IN MILLIMETERS.

Drops of Normal HcL or NaOH	Fuller's Scale	Day									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
+20	----------	----	----	----	----	----	----	----	----	----	----
+15	----------	----	----	----	----	----	----	----	----	----	----
+10	+40.55	0	0	0	0	0	0	0	0	0	0
+5	+20.55	0	2	3	5	7	12	16	16	18	18
0	+ .55	6	14	28	36	41	67	75	83	83	83
—5	—19.45	0	10	0	0	0	0	0	0	0	0
—10	—39.45	0	0	0	0	0	0	0	0	0	0
—15	—59.45	0	0	0	0	0	0	0	0	0	0
—20	—79.45	0	0	0	0	0	0	0	0	0	0
Date	December	11	12	13	14	15	17	18	19	20	21

It is seen that growth was inhibited by + 40.55 and — 19.45 of Fuller's scale. At + 20.55 growth was slow. At + 0.55 occurred the maximum growth.

Experiment 15. To determine the *toxicity of various fungicides* acting directly upon the mycelium.

Sclerotinia was grown in glass capsules in lettuce broth until a vigorous mycelium was obtained. The broth was then poured off and the mycelium was washed free of any remaining broth by allowing about one litre of sterile water to pass slowly through it by means of a small siphon. A small portion of the mycelium, the quantity as nearly equal as possible in all cases, was then transferred to the poison, the effect of which was to be tested. After ten minutes, one-third of this mycelium was removed, rinsed in several changes of sterile, distilled water and placed in tubes of sterile lettuce agar to test its viability. Other portions of the mycelium were similarly removed at the end of an hour and of twenty-four hours. The temperature of the poisons when used was approximately 21 degrees. The results are shown in table VI.

This experiment shows the inefficiency of a ten minute's application of such fungicides as ammoniacal-copper-carbonate, strong and weak Bordeaux, formalin 1 ounce to 1 gallon, and 1 ounce to 2 gallons, saturated lime water, and potassium permanganate 1 ounce to 10 gallons, though each of the above is fatal if applied for one hour.

TABLE VI.—SHOWING TOXICITY OF VARIOUS FUNGICIDES.

+ = viable; — = not viable.

Fungicide	Strength	10 Min.	1 Hr.	24 Hrs.
Ammoniacal Copper Carbonate	Copper Carbonate, 6 ozs.; Ammonia, 3 pts.; H_2O 50 gals.	+	—	—
Bordeaux Mixture	5 lbs. $CuSO_4$, 5 lbs. Lime, 50 gals. H_2O	+	—	—
Bordeaux Mixture	2 lbs. $CuSO_4$, 2 lbs. Lime, 50 gals. H_2O	+	—	—
Potassium Sulphide	1 oz. Potassium Sulphide, 1 gal. H_2O	+	+	+
Potassium Sulphide	1 oz. Potassium Sulphide, 3 gals. H_2O	+	+	+
Lead Acetate	1 oz. Lead Acetate, 1 gal. H_2O	+	+	+
Lead Acetate	4 ozs. Lead Acetate, 1 gal. H_2O	+	+	+
Potassium Permanganate	1 oz. Potassium Permanganate, 1 gals. H_2O	—	—	—
Potassium Permanganate	1 oz. Potassium Permanganate, 3 gals. H_2O	—	—	—
Potassium Permanganate	1 oz. Potassium Permanganate, 5 gals. H_2O	—	—	—
Potassium Permanganate	1 oz. Potassium Permanganate, 7 gals. H_2O	—	—	—
Potassium Permanganate	1 oz. Potassium Permanganate, 10 gals. H_2O	+	—	—
Formalin	1 oz. Formalin (40 %), 1 gal. H_2O	+	—	—
Formalin	1 oz. Formalin (40 %), 2 gals. H_2O	+	—	—
Formalin	1 oz. Formalin (40 %), 3 gals. H_2O	+	+	+
Sodium Benzoate	1 oz. Sodium Benzoate, 1 gal. H_2O	+	+	+
Sodium Benzoate	1 oz. Sodium Benzotte, 2 gals. H_2O	+	+	+
Sodium Benzoate	1 oz. Sodium Benzoate, 5 gals. H_2O	+	+	+
Sodium Benzoate-Bordeaux	½ lb. Sodium Benzoate, 1 lb. $CuSO_4$, 1 lb. Lime, 50 gals. H_2O	—	—	—
Iron Sulphate	15 %	+	+	+
Lime Water	Saturated	+	—	—
Lime Paste		—	—	—

Potassium sulphide, 1 ounce to 3 gallons and 1 ounce to 1 gallon, lead acetate 1 ounce to 1 gallon and 4 ounces to 1 gallon, formalin 1 ounce to 3 gallons, sodium benzoate 1 ounce to 1 gallon, 1 ounce to 2 gallons, 1 ounce to 5 gallons, and iron sulphate were not fatal even with a twenty-four-hour application.

Potassium permanganate 1 ounce to 1 gallon, 1 ounce to 3 gallons, 1 ounce to 5 gallons, and 1 ounce to 7 gallons, lime paste and sodium-benzoate-Bordeaux (one-half pound sodium benzoate, 1 pound copper sulphate, 1 pound lime to 50 gallons) were fatal even with the shortest period tested.

The inefficiency in these comparatively strong solutions of potassium sulphide and of formalin indicates considerable vigor and resistance on the part of the fungus.

Experiment 19. Copper sulphate was tested following the method of the last experiment, using strengths varying from N/100 to N/6400 and varying the time from 5 to 105 minutes. With the three weaker strengths, tests were made continuing to twenty-four hours. The tests were made with the solutions at a temperature of 17 degrees. The results are shown in the following table:

TABLE VII.—SHOWING TOXICITY OF COPPER SULPHATE.

o = Not viable; + = Viable.

Strength of Solution.	Time in Hours.																						
	1/12	1/6	1/4	1/3	5/12	1/2	7/12	2/3	3/4	5/6	11/12	1	1 1/12	1 1/6	1 1/4	1 1/3	1 5/12	1 1/2	1 7/12	1 2/3	1 3/4	4	8	24
n/100	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o
n/200	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	o	o	o	o	o	o	o	o
n/400	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	o	o	o
n/800	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	o	o	o
n/1600	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
n/3200	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
n/6400	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

In all cases here copper sulphate failed to cause death of the mycelium, until the mycelium had been subjected to the solution for 80 minutes. It then caused death with the two stronger solutions, N/100 and N/200. N/400 and N/800 did not cause death till the expiration of 105 minutes, and even 24 hours soaking in the three weaker solutions, N/1600, N/3200 and N/6400, failed to kill the fungus.

In conditions unfavorable to mycelial growth, for example upon plain agar, or agar otherwise deficient in nutrients the gonidia were produced in abundance. Their production also occurred in the midst of dense masses of mycelium in late periods, apparently due to the unfavorable effects of lack of nutrients or to the development of inhibiting products. They were also formed abundantly from the germ tubes of ascospores in drop cultures in sterile water within a few days after the cultures were made. Here no nutriment was accessible except that present in the spore itself.

Careful count was made of the number of sclerotia upon various parts of affected lettuce plants. The results are given in Table IX.

These plants were naturally infected in the lettuce beds. It is seen that the greater number of sclerotia was formed in the axils of the leaves around the stem. Those formed in the ground on the root were produced only after the root had begun to decay. No plants that were examined, in which the roots had not begun to decay, showed signs of sclerotia below ground and in very few instances was there any external sign of the fungus in the parts below ground.

If half of a bed of the usual size, 9 x 100 feet, bearing 2,000 plants, be diseased (this is not an uncommon percentage), it is seen that there may be formed as many as 17,100 sclerotia per bed. It is quite certain that this estimate does not fully represent the actual number formed under conditions of badly infected beds.

TABLE VIII.—SHOWING DISTRIBUTION OF SCLEROTIA IN THE PLANT.

Plant No.	On Ground	In Axils of Leaves	Among Leaves	On Ground in Root	Total
1		9	2	1	12
2		9		2	11
3		9			9
4	1	14	8	10	33
5		9	1	4	14
6		13	2	4	19
7		8	14	4	26
8		23	1		24
9		10		4	14
10		9			9
Total	1	113	28	29	171
Average	1	11.3	2.8	2.9	17.1

Sclerotia can be grown upon a great variety of media but upon some media they do not develop in any large quantity. They were formed upon the surface of the lettuce broth cultures after the mycelium had grown to a considerable extent, thus forming a support for them; but sclerotia have never been seen to form within the liquid medium itself and plants brought into the laboratory and kept in culture dishes where they became very wet did not form as many sclerotia as those placed upon soil in the greenhouse where the plants were less wet.

In a test of plain agar, plain agar plus 1 per cent. glucose, plain agar plus 5 per cent. glucose, plain agar plus 1 per cent. peptone, plain agar plus litmus-lactose, plain agar plus 1 per cent. starch and lettuce agar, it was seen that sclerotia formed in all the media except those which contained peptone or litmus-lactose. In a test of temperature relations no sclerotia developed in the higher temperatures, above twenty-six degrees C.; nor at the lower temperatures, below eight degrees C. The formation of sclerotia is inhibited by these extremes before the growth of the mycelium is stopped.

Two cultures of Sclerotinia upon the corn meal saturated with apple juice, in 20 cm. culture dishes, were inoculated January 17, 1907, and the first mature sclerotia were picked from these cultures on January 28th, 11 days from inoculation.

From these cultures full size, black sclerotia were taken every alternate day until February 8th, then every third day until February 17th; a period in all of one month from the date of inoculation. During this time one of the cultures produced 523 sclerotia and the other 397 or a total of 920 for the two cultures. The following table shows the number of sclerotia taken on each date.

TABLE IX.—SHOWING SCLEROTIA PRODUCTION IN CULTURES.

Date	Jan. 28, '07	Jan. 30, '07	Feb. 2, '07	Feb. 4, '07	Feb. 6, '07	Feb. 8, '07	Feb. 11, '07	Feb. 14, '07	Feb. 17, '07	Total
Sclerotia taken from Culture, A	52	39	105	10	39	75	67	65	71	523
Sclerotia taken from Culture, B	52	89	39	75	10	41	29	26	36	397
Total	104	128	144	85	49	116	96	91	107	920

The formation of sclerotia seems dependent upon the attainment of a certain mycelial density. Thus upon a rich medium, as corn meal, continued branching accompanied by radial enlargement of the colony

FIG. 21.—Sclerotia produced in culture upon corn meal wetted with apple broth, showing concentric rings of sclerotia around the central point of inoculation.

soon leads to mycelial crowding. A quite regular ring or zone of sclerotia results, Fig. 21. Again radial expansion begins and after a certain interval another ring of sclerotia is produced. This alternation is repeated indefinitely.

When several colonies are so located that they meet mycelial crowding must occur at the points of contact. Here, too, sclerotia develop in abundance, Fig. 22. Attention has been called elsewhere,[18] to the importance of mycelial crowding as a stimulus.

FIG. 22.—Sclerotia produced in culture upon corn meal wetted with apple broth, showing rows of sclerotia where colonies met.

To determine the length of time necessary for sclerotia to mature, for germination, a large number of sclerotia was taken from corn meal cultures and air dried for a few days. They were then planted in pots of sterilized soil at periods of a week apart. At each of these plantings old sclerotia, that were known to be mature, were also planted as controls. All of these grew, even those which were picked and merely air dried for a day or so showing as vigorous germination as did the old sclerotia. It thus appears that sclerotia are mature as soon as formed and are ready to germinate at once if favorable conditions obtain.

Attempts were made to determine the length of life of sclerotia under laboratory conditions and lettuce bed conditions. In the laboratory sclerotia were stored in ordinary room temperature, one lot in the dark all the time, another lot alternately in the light and dark of day and night, a third lot was kept wet all the time. Three similar sets were kept in the incubator room (temperature 37 degrees). At the end of 11 months those kept wet were found to have all decayed. Of those kept dry a little more than one-third (24 out of 60) produced ascophores normally. In an out-door test a large quantity of sclerotia was collected, placed in the lettuce beds at one-half inch depth in March. These were examined twice during the early part of the summer and were all sound. The third examination was made August 11, 1909 (five months and eleven days after placing them in the soil) and it was found that they had all decayed and the only thing left was the hard, black, parenchymatous, shell-like outside coverings and a very few of the thread-like stumps of stipes, abortive attempts at germination. While the longevity of the sclerotia under conditions most favorable to them has not yet been determined, it is evident that *under usual conditions their number must be largely reduced by decay.*

Germination of Sclerotia.

To determine the conditions most favorable to their germination sclerotia were placed:

(1) In ordinary three-inch flower pots filled with soil and these placed in a shallow dish of water. The pots were covered with strips of bibulous paper with the ends bent down into the water. The sclerotia were pressed into the soil until they were just level with the surface.

(2) Similar pots were prepared in the same way and placed in the incubator room and covered with bell jars instead of paper.

(3) Pots were placed outdoors on the north side of the building in a shady and cool location.

(4) Pots prepared as in the first case but not covered with paper were kept in the laboratory taking precaution only to keep water in the dish in which they were placed.

Ascophores were produced in all cases except under the incubator room conditions in which case no ascophores were formed until the pots were removed to the laboratory. The fourth method was found to be the most satisfactory and convenient for laboratory use.

Apothecia produced under unequal illumination are strongly positively phototropic turning their disk faces toward the source of light.

An experiment was made to determine the maximum depth in the soil at which sclerotia would germinate and produce apothecia. Three six-inch flower pots were filled with soil and each pot was divided into two compartments by glass partitions, sclerotia were then planted at depths of 1-2, 1, 1 1-2, 2, 2 1-2, and 3 inches. No apothecia were formed from sclerotia placed at a greater depth than 1 1-2 inches and by far the largest number of apothecia was formed from sclerotia at the minimum of the above depths.

To study the effect of stirring the soil over the sclerotia when in conditions favorable to their germination sclerotia were planted in soil in a two-foot flat in the laboratory and kept properly watered. Half of the flat was left intact and undisturbed. In the other half the soil surface was stirred or hoed every two weeks. In the undisturbed half apothecia were formed normally. More than 10 were counted at 25 days after planting. In the half of the flat in (Fig. 23) which the soil was stirred, no apothecia at all were formed even after 60 days' test.

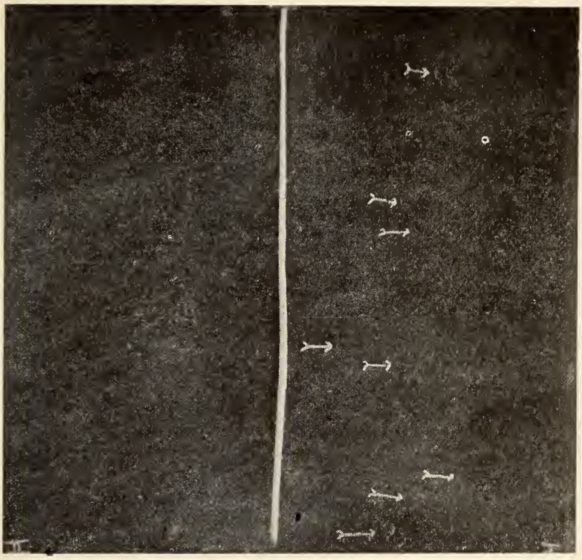


Fig. 23.—Flat showing the effect of stirring the soil upon the formation of apothecia. 1, Not stirred. 2, stirred every two weeks.

The Ascophore.

To determine the effect of mutilation of the ascophore, sclerotia were germinated and the stipes, as soon as they began to expand, were cut off at various distances from the apex. It was found that these stipes ceased to develop, except when they were cut just at the base of the forming disk. In such cases, however, new disks began to develop at once and sometimes two or three appeared upon the end of one mutilated stipe, Fig. 24.

To ascertain the effect of light or darkness upon the formation of the ascophore a flat was divided into four sections and planted December 14, 1906, with sclerotia. The first section was left uncovered, the second was covered with unprinted newspaper, the third with light weight manilla paper and the fourth with heavy weight manilla paper. Examination on February 5, 1907, showed that disks were fully formed upon section one, uncovered, though no disks showed in any of the other sections (Fig. 25). On February 27 the paper was all removed, and on March 11 very numerous disks were first observed on these newly uncovered sections. The time which elapsed between the removal of the paper and the appearance of the disks was considerably less than is usually taken to produce ascophores and it is probable that the presence of the paper simply inhibited the formation of the disks, not of the stipe of the ascophore. Light is evidently the stimulus which causes the tip of the sprouts which come from

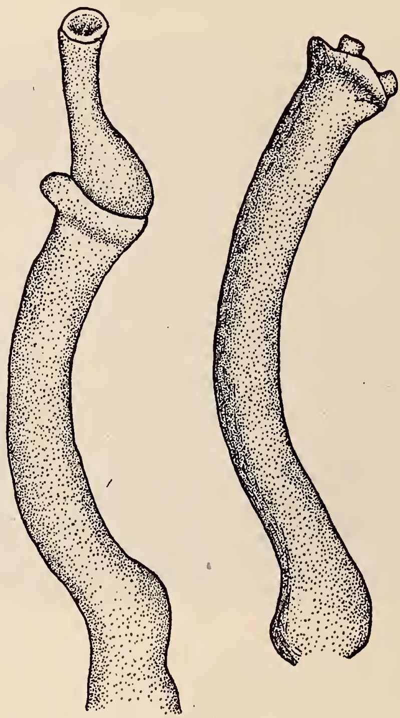


FIG. 24.—Ascophores, showing new disk formation after mutilation.

the sclerotium to stop growing in length and to expand into the disks and the presence of the paper covering was probably sufficient to exclude the light and thus to prevent this reaction.

As shown on page 118 heat or cold beyond certain limits retards or inhibits the formation of ascophores. The maximum temperature for ascophore formation seems to be about 8 to 25 degrees C.

THE ASCOSPORES.

The ascospores, as has frequently been noted, are discharged quite forcibly into the air when mature. To observe this phenomenon sclerotia-bearing disks were grown in flower pots and covered with plates of glass, or kept in tea cups covered with damp cloth. Upon the removal of the covering clouds of spores were forcibly ejected and could be followed by the eye for a distance of several feet. Currents of air caused by any one passing rapidly by ripe disks in open pots caused the ejection of spores. Spores for study were readily secured at any time by placing a cover glass over a ripe disk, then breathing lightly upon it, resulting in an immediate and copious discharge of spores upon the cover glass.

To determine the per cent. of germination of ascospores and the toxic effect of copper sulphate, Bordeaux-mixture-filtrate and other substances hanging drop cultures were made in lettuce broth, in distilled water and tap water, also in various toxic substances. The tests were

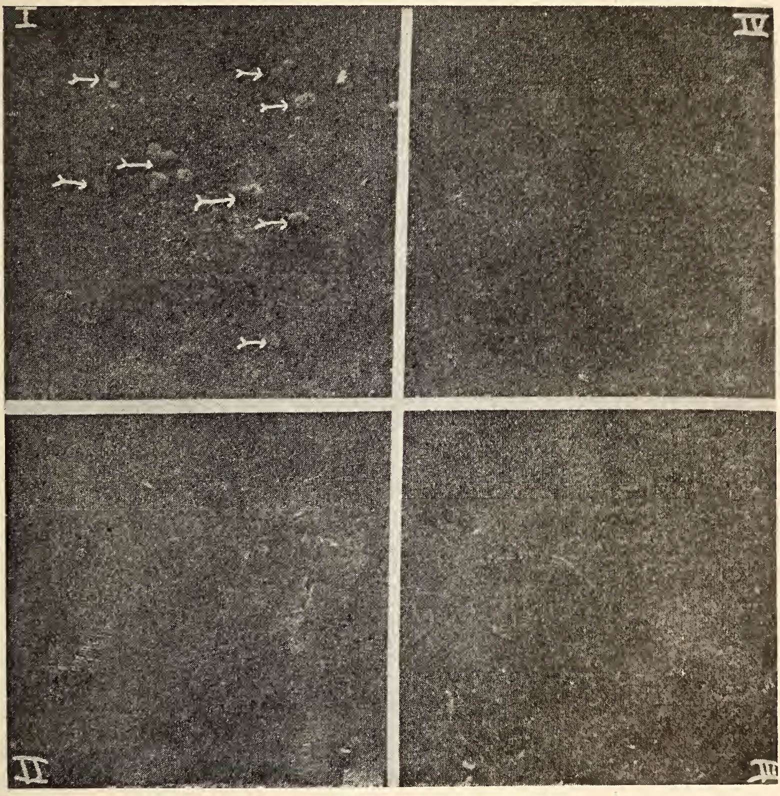


Fig. 25.—Flat showing effects of different coverings upon the development of apothecia. I, Not covered; II, covered with heavy manila paper; III, covered with light manila paper; IV, covered with unprinted newspaper.

made by catching spores upon cover glasses by the method described above and preparing hanging drops with these, using the solution to be tested. The percentage of germination was read when the spores ceased to germinate.

Bordeaux filtrate No. 1 was made by merely filtering freshly prepared Bordeaux Mixture. The residue remaining upon the filter paper was then allowed to dry and remain thus one week. It was then washed with the least possible quantity of water and this wash water filtering through was tested as Bordeauz filtrate No. 2.

The result of these tests are shown in the following table:

TABLE X.—SHOWING EFFECT OF VARIOUS SUBSTANCES UPON SPORE GERMINATION.

Medium used.	Germination, Per Cent
Water distilled from Bichromate of Potash.	68
Distilled Water with Lamp-black added, then filtered.	80
Ordinary Distilled Water.	85
Tap Water.	92
Lettuce Broth.	100
Copper Sulphate solution $\frac{n}{100}$	0
Copper Sulphate solution $\frac{n}{200}$	0
Copper sulphate solution $\frac{n}{800}$	0
Copper Sulphate solution $\frac{n}{1600}$	10
Copper Sulphate solution $\frac{n}{3200}$	20
Copper Sulphate solution $\frac{n}{6400}$	50
Bordeaux Mixture, Filtrate No. 1.	0
Bordeaux Mixture, Filtrate No. 2.	100

It is seen here that germination was more in ordinary distilled water than in the supposedly non-toxic water (U. S. Bureau of Soils) and that still higher germination was attained in tap water and higher yet in the nutrient lettuce broth. Copper sulphate N/800 is fatal to all of the spores and only 10 per cent. germination was found in the N/1600. The per cent. of germination increased almost in proportion to the weakening of the solution beyond this point. In the case of the Bordeaux filtrate it is seen that the first filtrate was fatal to all the spores while the second did not prevent germination at all.

To test the longevity of ascospores, collections were made on cover glasses and placed away in sterile petri dishes. These were tested in duplicate or triplicate the first and second day and every seventh day thereafter until no germination was apparent, using either lettuce broth or 4 per cent. sugar solution as the medium. The results of these tests appear below:

TABLE XI.—SHOWING LONGEVITY OF ASCOSPORES.

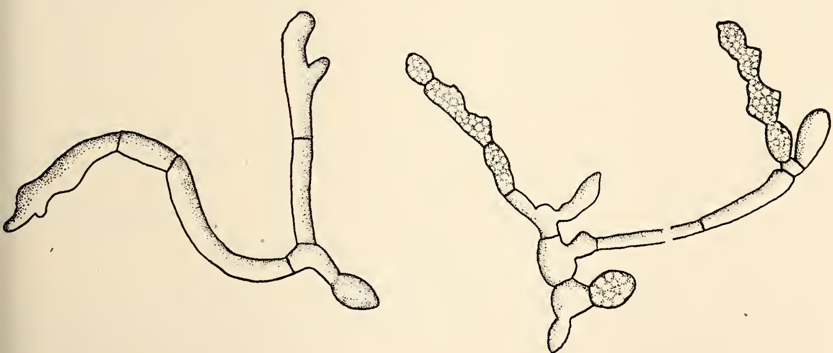
Age in Days.	1	2	7	14	21	28	35	42	49	56	63	70	77	84	91
Per Cent of Germination.	100	100	25	50	50	65	10	50	50	90	75	95	90	90	50
Medium Used in Cultures.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	4% Sugar.	4% Sugar.	4% Sugar.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	4% Sugar Solution.

TABLE XI—CONTINUED.

Age in Days.	98	105	112	119	126	133	140	147	154	161	168	175	182	189
Per Cent of Germination.	90	75	75	50	75	50	25	10	1	0	0	0	0	0
Medium Used in Cultures.	4% Sugar Solution.	4% Sugar Solution.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.	Lettuce Broth.

While there is considerable fluctuation in the results the gradual falling off in germinations after the 125th day and the total lack of germination after 154 days or about 5 months seems to indicate that the ascospores do not live longer than this time. It is to be noted that the spores in these instances were kept dry. If they were allowed to become moist, as through absorption of water from a humid atmosphere, they immediately germinated. It is thus apparent that their only condition of longevity is in a dry state and that the results reported above therefore, represent their maximum life. Under other, perhaps under all normal conditions, their life is undoubtedly short.

In some cases cultures of ascopores in the sugar solution were examined after 26 hours. It was found that while at first growth had



a b

FIG. 26.—Germinating ascospores. *a*, Normal; *b*, abnormal from sugar solution.

been normal, Fig. 26a, very much distorted hyphæ, Fig. 26b, occurred in abundance and that the distorted cells were vacuolate after the manner of old hyphæ.

INFECTION BY ASCOSPORES.

The question of infection conditions is one of highest importance. Many tests were made to determine under what conditions ascospores could produce infection. The following trials are typical:

A number of fresh, healthy lettuce leaves was placed in culture dishes and inoculated with ascospores in the ways indicated below.

The checks were exact parallels of the inoculations but without spores. The results of these inoculations are shown in the following table:

TABLE XII.—REGARDING INFECTION BY ASCOSPORES.

Number of Leaves Inoculated	Methods of Inoculation	Surface of Leaf Inoculated	Number of Leaves Infected in 7 Days
10	Ascospores in lettuce broth	Upper	6
10	Ascospores in lettuce broth	Lower	0
10	Ascospores in water on bruised spot of leaf	Both	5
10	Check	Upper	0
10	Check	Lower	0
10	Ascospores in water	Upper	0
10	Ascospores in water	Lower	0
5	Ascospores at needle-prick	Upper	0
5	Ascospores at needle-prick	Lower	0

It is noted that the only infections occurred in the presence of the nutrient lettuce broth or at the bruised spots where, virtually, broth existed. This lack of ability of the spores alone, or in water merely, to infect was of such importance that repeated tests of this point were made.

Thus on November 21, 1907, ten lettuce leaves were inoculated upon the upper surface with ascospores in sterile water and on December 3, 1907, there was still no sign of infection.

On November 21, 1907, fifteen lettuce leaves were inoculated upon the lower surface with ascospores in sterile water and on December 3, 1907, there was still no sign of infection.

In both of these cases the leaves, kept in a damp chamber in ordinary room temperature, were fresh and healthy at the end of the experiment, even at the marked spots where the spores were placed. On December 4, 1907, spores were washed from the leaves which had been inoculated but which had shown no infection. Upon microscopic examination in all cases where the spores were found it was seen that they had germinated in a normal way but with no branching of the mycelium or flattening of its end. It was thus made clear that the lack of infection was not due to non-viability of the spores.

On December 4, 1907, sixteen lettuce leaves were inoculated in a damp chamber with spores placed in lettuce broth together with small pieces of lettuce leaf; of these, nine leaves became diseased in seven days while seven showed no infection. At the same time sixteen more leaves were prepared in the same way except that sterile water was used in place of the lettuce broth. In this case none of the leaves showed infection on the seventh day and it was not until the twelfth day that any signs of infection were seen. The leaves had by that time wilted badly and these three cases can not be regarded as cases of parasitism.

To still further study infection by ascospores leaves were inoculated as is indicated in Table XIII. In the case of the inoculations with mycelium the vigorously growing mycelium was placed upon cover glasses in a drop of lettuce broth so that only the tips of the mycelium could touch the leaf by growing over the edge of the cover glass. The leaves were kept in culture dishes so as to preserve a humid atmosphere.

TABLE XIII.—REGARDING INFECTION BY ASCOSPORES.

Number of Leaves	Surface of Leaf	Ascospores + Sterile Water	Ascospores + Lettuce Broth	Mycelium
10	Upper	No leaves infected	No leaves infected	10 leaves infected
10	Lower	2 leaves infected	10 leaves infected	10 leaves infected
10	Bruise	2 leaves infected	10 leaves infected	10 leaves infected
10	Control	No leaves infected	No leaves infected	No leaves infected

Summarizing all of the experiments upon this point, it appears that direct infection by ascospores seldom, if ever, occurs but that infection from the mycelium follows in 100 per cent. of the cases. Spores placed upon a lettuce leaf in lettuce broth with a small bit of torn lettuce leaf also gave a reasonably high per cent. of infection. The use of a drop of lettuce broth upon the leaf in which to place the spores also usually gave infection. In only two cases, however, of all the trials made did any infection result from placing spores upon the leaves in pure water or upon the bare surface of the leaf. In view of this very small percentage of positive results we are not willing to accept this as evidence that the fungus can ever enter upon its parasitic existence without at first having attained vigorous headway saprophytically.

Parasitism and Saprophytism.

The fungus is clearly a saprophyte under many conditions as is attested by its luxuriant growth on various nutrient media and upon dead organic matter. That it may be parasitic as well is obvious from its inroads upon lettuce in our experiment beds and in many commercial beds of this State. The exact degree of its parasiticism and the extent to which it can exist as a saprophyte can, however, only be told by careful experimental work. Since these relations are of great economic significance, with strong bearing upon methods of prophylaxis, close attention was given to ascertain under what conditions and at what stages of its development this fungus is capable of paracitism and how long and upon what nutrients it can exist as a saprophyte, and in particular to what extent it can exist in and migrate through soil.

The following additional test of ascosporic infection was made. Thirty lettuce leaves were placed in culture dishes and upon the first ten was placed sterile soil, upon the second ten sterile soil with ascospores upon the soil. At the edges of ten other leaves small pieces of manure were placed with ascospores on the edges of the manure which were farthest away from the lettuce leaf.

There was no infection in either the first or second case through soil while in the third case the spores germinated, grew over the manure and speedily caused the disease upon each of the ten leaves. It appears from this and other experiments previously quoted that ascospores are not capable of direct infection of the lettuce plant but

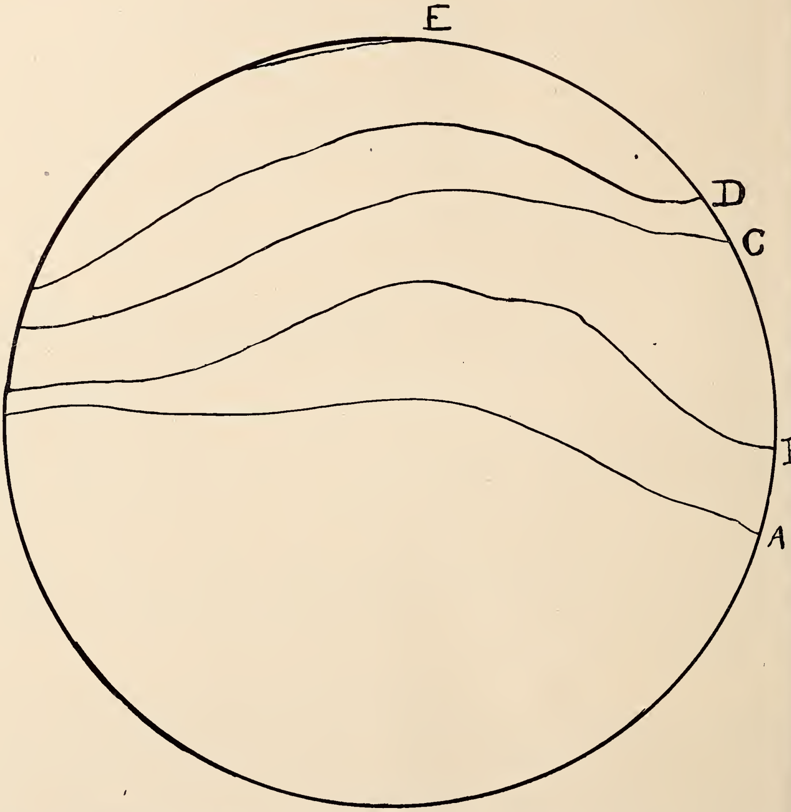


FIG. 27.—Diagram showing rate of invasion of a lettuce leaf by Sclerotinia. Each zone represents one day's growth.

that the germ tubes formed from the ascospores must acquire a considerable strength and develop a vigorous mycelium by a saprophytic habit before they can bring about infection of healthy tissue. Even the nutriment present in ordinary rich soil will not give the mycelium vigor sufficient to produce infection.

To fully demonstrate the parasitism of the ordinary vigorous mycelium the following test was made: On December 30, 1907, ninety-six plants in outdoor beds were inoculated at various places with masses of vigorously growing mycelium, some placed as near the center of the head as was possible without tearing the plant seriously, others by laying the mycelium upon the lower leaves on the shaded side of the plant. All of these plants showed clear cases of infection at the end of fifteen days or earlier, and all the plants were dead and dried up on the first of April, 1908.

To determine the rapidity of growth of the mycelium of the fungus in a plant and its migration through the tissues of the plant a leaf, after it had become infected on one edge, was placed in a large petri dish and daily record was made of the growth of the mycelium by marking the outside of the plate. The daily growth as is shown by the accompanying diagram, Fig. 27, was on an average, about 11 mm., while the maximum for a single day was 15 mm. and the minimum for the same period 8 mm. The lines of the diagram indicating the growth each day, represent as nearly as possible, the place where the green and uninfected portion of the leaf joined the translucent or infected portion. The average temperature for the five days was 54.5 degrees F. with a maximum of 75 degrees and a minimum of 39 degrees.

After the mycelium exhausts the food supply from the portions of the plant which are attacked, it reaches into the air or over the earth; no aerial mycelium is noted upon newly infected tissue.

The Maximum Infection Distance for Mycelium.

A few lettuce leaves were placed on moist sand in a glass dish, inoculated and kept covered. After a vigorous growth had developed and the originally infected leaves were nearly consumed fresh leaves were placed at various distances from the infected mass. The maximum distance at which leaves were infected in this way, i. e., the maximum distance that the fungus could travel under such conditions, was 2.5 cm. White mycelium might be seen with the naked eye to a distance of about 8 mm. from its source of nourishment, no farther. A very few small sclerotia formed on the naked sand near the lettuce leaf.

In order to determine to how great a distance the mycelium would spread over strictly non-nutritious surfaces small pieces of lettuce leaf were laid in a large sterile petri dish and inoculated with mycelium. The dish was then placed in a moist chamber. The following is the record showing the distance to which the mycelium spread, using various amounts of lettuce leaf for inoculation.

It is evident that with a very small amount of lettuce from which to draw nourishment the mycelium spreads only a short distance. By increasing the amount of nutrient material the distances to which the mycelium can spread is increased up to a maximum of about 22 or 23 mm. It is thus apparent that the spread of this fungus over a soil to any great distance, unless the soil provide nutrient material, is not to be feared. It is noted also in this experiment with the small amount of nutrient material such as 50 sq. mm. of lettuce leaf no sclerotia are formed. With as much as 100 sq. mm., however, a sclerotium, though small, was made.

Mycelium was placed so that its tips only might come in contact with a lettuce leaf. In twenty-four hours it had grown to the leaf, and had developed holdfasts at each point of contact. Each holdfast was surrounded by a translucent spot 1 to 2 mm. in diameter. In twenty-four hours more the tissues were translucent to a distance of about 2 cm. in each direction from the point of original infection, though there was no development of mycelium external to the leaf except near the petiole where the nutriment afforded by the tissues was apparently exhausted.

TABLE XIV.—SHOWING DISTANCE OF MYCELIAL GROWTH, ON GLASS.

Amount of Lettuce Leaf	Distance of Mycelial Growth	Remarks
4 sq. mm	4 mm	About equally in all directions.
50 sq. mm	7 mm	
100 sq. mm	8 mm	Irregularly, one small pin-head-sized sclerotium was formed.
200 sq. mm	18 mm	Irregularly, one small pin-head-sized sclerotium was formed.
400 sq. mm	23 mm	Irregularly, one small pin-head-sized sclerotium was formed.
900 sq. mm	22 mm	Irregularly, one small pin-head-sized sclerotium was formed.

Numerous attempts were made to infect lettuce leaves with soil taken from beneath diseased plants and which was known to contain the mycelium, since it was clearly visible to the naked eye.

Thus, on February 8, 1908, fifty lots of such infected soil were taken was aseptic precautions by a sterilized spatula and placed upon healthy lettuce leaves in sterile culture dishes and dampened with sterile water. No infection resulted. It seems from these tests that the mycelium can not migrate far through soil and retain its infecting efficiency without additional organic food.

Hosts.

While this species of fungus has been reported upon many hosts it is notable that during all of our work of the past four years, involving the inspection of many infected beds in many localities, only two cases of the attack of this fungus in lettuce beds upon any plant other than lettuce have come under our observation. One of these cases was as follows:

A garden pea about 30 cm. high of vigorous though somewhat forced growth, was bent over into contact with the mycelium of the diseased lettuce leaf in the experiment mentioned on page 127. In eight days the distal end of the pea, some 12 cm. long, had been killed. Mycelium was breaking out through it in numerous wooly patches and sclerotia had begun to form. The fungus had also migrated some 9 cm. toward the root and for about 5 cm. the stem was covered with floccose mycelium (Fig 28). The invasion of the pea stem continued until the entire plant was killed.

In the other case B. B. Higgins observed a plant of Lamium which lay amid a mass of sclerotinized lettuce and had become infected. Both of these cases are exceptional. This rarity of infection of plants other than lettuce points somewhat strongly to specialization of the fungus or to very low resistance by the lettuce plant.

Sclerotinia libertiana has been reported on many other hosts and has been found in North Carolina upon a few others besides lettuce. B. B. Higgins brought it into the laboratory on cabbage and a sclerotium disease that appears to be identical with it was sent to the Ex-

FIG. 28.—Showing healthy leaves and two infected leaves lying upon soil; also an infected pea vine.

periment Station from Mebane by S. K. Scott upon crimson clover and by B. T. Pierce from Charlotte upon alfalfa. According to all appearances of the mycelial growth and formation of sclerotia these are identical but as the sclerotia were not large enough to produce asci and ascospores no comparative data on those structures were obtainable.

Among the hosts upon which the fungus has been reported are the following:

Upon Hemp in Russia, 1868.
" Potato in England, 1883.
" Bean in Germany, 1886, and in Holland.
" Petunia in Germany, 1886.

Upon Zinnia in Germany, 1886.
" Hemp in Alsace, 1891.
" Hollyhock in England, 1891.
" Cucumbers in Massachusetts, 1893.
" Mulberries in France, 1897.
" Sunflower, Dahlia, Eimia, Beets in Holland.
" Artichokes in France, 1899.
" Carrots in France, 1899.
" Chicory in France, 1899.
" Tomatoes in Massachusetts, 1900.
" Cauliflower in Missouri, 1905.
" Cabbage in Missouri, 1905.
" Artichokes in France, 1905.
" Forsythia in Switzerland, 1905.
" Lemon in California, 1907.
" Omphalodes in Switzerland, 1909.

Also upon Ægopodium, Cerefolium, beets, radish, chicory, mustard, rape, caraway, parsley, celery, fennel, vetch, clover.

Field Observations.

Study of diseased plants in New Bern in 1906 showed that the plants were generally attacked on the lower leaves at spots where they touched the soil. The fungus then worked both ways, toward the stem of the plant and toward the tip of the leaf, though it stops its migration in the latter direction very soon owing to the lack of moisture. Growing toward the stem of the plant it soon reaches the leaf axil and there forms masses of white cottony mycelium and eventually sclerotia. The greater number of sclerotia are formed here although some are formed at other points especially among the leaves that lie upon the ground.

Some time was spent sifting the soil, looking for sclerotia formed the previous year. From a bed that was badly infected it was difficult to get an average of more than one sclerotium from each two-quart sifter of soil.

Many germinated, disk-bearing sclerotia were found, nearly always in the front of the beds where the soil was shaded nearly all of the time. When disk-bearing sclerotia occurred in other parts of the beds it was always either in places where they could not be disturbed by cultivation or in beds that had not been recently cultivated. Germinated sclerotia were especially abundant under lettuce plants where they were both shaded and protected from mechanical disturbance. In the case of about half of the affected plants the diseased portion was either directly over a disk-bearing sclerotium or the faces of near by disks were turned toward the infected plant. In the latter case the plants invariably showed more disease upon the side of the plant nearest the disk. It was no uncommon thing to see clouds of spores discharged from disks in the field.

Disks were found upon sclerotia that were located at a depth of 1 1-2 inches in the soil. In no case were sclerotia found upon or mong the roots of a plant that had just died. The root was always till perfectly sound, even after the aerial portion of the plant was ntirely dead and in no case were sclerotia found in the soil until the oot had had sufficient time to rot.

General Relation of the Fungus in Nature.

From the facts above adduced experimentally and from field obervation it is seen that *Sclerotinia libertiana,* which is the actual ause of the disease under discussion, propagates and spreads by means f its ascospores produced from the germinated sclerotia and by its aycelium.

The ascospores are comparatively short-lived, even under the conitions most favorable to their longevity. In condition of nature, subect to alternate dryness and atmospheric humidity they would invaribly germinate and in the absence of favorable nutrient pabulum, die. 'hus the ascospores can not function to any large degree as a means f carrying this fungus over periods of time of any considerable duraion.

The mycelium has also been shown to be of comparatively short-life nd to retain its infecting power but a short time in the absence of utriment. This, too, can not be regarded as a means of carrying the ungus over long time intervals. Any possibility that the mycelium aay remain alive in soil that has borne sclerotinized plants is very emote, probably non-existent. The sclerotium is long-lived and well dapted to perpetuate the fungus. It alone, of all the structures of the ungus, is able to live for sufficiently long periods to bridge over easons adverse to the growth of the fungus or long periods of time 'hen no food is available.

The fungus may, therefore, be likened to an annual plant, all parts f which except the seed die at the approach of winter, the sclerotium ı this instance acting the rôle of the seed.

The sclerotia rest during the period of inactivity of the disease, that from the harvest of one lettuce crop until the next crop is present nder suitable weather conditions to permit of infection. They then erminate and produce apothecia with a crop of myriads of ascospores. These ascospores have been shown unable to directly infect healthy ttuce leaves. They may germinate in the film of dew upon the plant ıt can not force entrance into its tissue and can only perish. Neither 'e mere wounds ordinarily sufficient to allow infection. The ascoores must at first sustain a period of saprophytic existence until the ycelium developing from it attains a certain degree of vigor. To do is the ascopores must fall upon and germinate upon organic matter, ad moist leaves or other plant parts or particles of manure or some her similar dead organic substance. A dead lettuce leaf or torn agment of leaf serves its purpose admirably. If the saprophytic istence of the sporeling be upon organic matter which lies very ar a lettuce plant the vigorous mycelium may reach over to it and rasitize it.

In cases where the ascospores fall upon dead lettuce leaf fragments still in contact with the live lettuce plant the infection bridge is open. If the ascospores fall upon organic matter separated by some centimeters from the lettuce plant the organic matter there available will be consumed and the mycelium will perish without any infection resulting. In some instances when the food supply is fairly large new sclerotia may be formed. Migration of the mycelium through the soil in efficient infecting condition, for any considerable distance, does not occur, even in soils bearing a large amount of organic matter as reckoned by the horticulturist.

Infection from plant to plant is governed by these same conditions. If the infected plant lie sufficiently near to the uninfected one, the distance can be bridged by the mycelium, but this does not occur at any great distance, usually not over a few centimeters.

That infection from plant to plant does not bridge over any large distance is shown by many observations of healthy plants standing, surrounded on all sides, by dead sclerotinized plants.

Attempts to Control the Disease.

According to Stone[9] the lettuce sclerotiniose became so bad in many green-houses in Massachusetts that many growers lost practically their whole crop from this cause. Disinfection of the soil, however, proved practicable under green-house conditions.

Two principal methods of soil disinfection were early used (1) by means of chemical solutions; (2) by means of heat. The first of these methods has been proved to be unsatisfactory and impractical in most cases. The second has been of a very great benefit.

One of the earlier methods for heating the soil was to sprinkle it with hot water. This was of some value but not entirely effective and moreover it possessed the disadvantage that it left the bed so wet that it had to remain idle for considerable time in order to become dry enough to be worked.

The substitution of steam as a disinfectant followed and it is today used with considerable success under green-house conditions. There are three ways in which steam may be used: (1) by placing 2-inch drain tile permanently under the soil in rows 16 inches apart, more or less as circumstances dictate, and flooding them with steam; (2) by laying perforated steam pipes upon the soil in the middle of the bed and throwing the soil from the sides upon them, then heating by steam, and after steaming pulling out the pipes to use elsewhere. The soil is then covered with canvas for several hours; (3) by a harrow-like arrangement of pipes. Fig. 29. The teeth of the harrow are perforated on all sides to allow the steam to escape into the soil. The teeth are driven into the soil to a depth of perhaps 10 inches and heated to 208 degrees F., and this temperature maintained as long as is desired.

The disinfection of green-house soil in some of these ways has been used in Rhode Island,[20] Vermont,[21] Ohio,[22] and some other States nearly always with beneficial results.

In Kentucky,[11] a drop* is reported to have been checked by sub-irrigating and placing a mulch of excelsior under the plants to prevent their touching the soil.

FIG. 29.—Steaming the soil by means of Sargent's sterilizer.

To test the applicability of the above well-known methods to the cold frame and field conditions of the South, numerous experiments were planned and carried out at New Bern and West Raleigh, some of which were as follows:

Experiment 3. To test the efficiency of soil disinfection by heat. One-half of a bed designated as Bed A was prepared by laying 2-inch drain tile 10 inches deep and about 13 inches apart with the ends

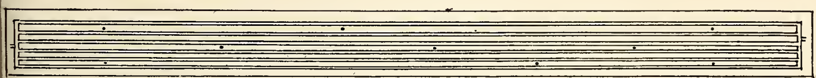


FIG. 30.—Showing the arrangement of tile in box used for steaming the soil for top dressing. Ends of tile, *b*, were closed with cement.

all running into cross tile as shown in Fig. 30. Thermometers were placed in the soil, care being taken not to place any of them over the rows of tile.

*It is uncertain whether this was sclerotiniose or some other form of drop.

TABLE XV.—SHOWING TIME AND TEMPERATURE IN SOIL STERILIZATION EXPERIMENTS.

Time	12:30	12:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00	4:15	4:30	4:45	5:00	5:15
Therm. a	8	10.5	14	21	25	35	45	46	55	65	74	78	85	90	95	60	70	89	95	95
" b	8	10.5	13	17	21	25	31	38	40	45	50	56	59	63	66	69	72	75	76	80
" c	9	9	10	14	20	30	40	57	70	80	89	94	51	63	85	90	95	95	95	95
" d	7	10.5	22	30	36	46	50	55	60	65	70	74	76	85	50	69	85	90	90	95
" e	8.5	9	9	9	11	11	13	15	15	17	22	28	33	41	57	80	92	95	95	95
" f	10	11	11	11	11	11.5	12	13	14	16	18	19	23	38	67	90	92	95	95	95
" g	7.5	8	8.5	8.5	9	9	9	10	10	10	11	11	12	14	20	28	60	74	80	90
" h	8	8.5	9	9	9	9	9.5	9.5	10	10.5	10.5	11	11.5	12	12.5	20	40	59	72	80
" i	8	8.5	8.5	9	9	10	10	10	10	10	10	10.5	11	12	21	60	95	95	95	95
Steam pressure in lbs.	65	60	60	60	58	45	60	60	60	60	65	60	60	60	65	60	60	60	60	60

Records were taken of the temperature at each thermometer every 15 minutes from the time steam was turned on until the end of the steaming, also of the steam pressure on the boiler (see table).

In this bed were planted 1,260 lettuce plants, care being taken to prevent the carrying of the disease into the bed from other infected beds; of these plants 88 or 6.98 per cent. had the characteristic disease. In the control bed, B, of 1,260 plants there were only 38 that showed the disease. This discrepancy may be accounted for by the fact that infection was worse in Bed A, before it was treated; but it is evident that such steaming did not give promise as a method of control.

Beds G and H were steamed with the Sargent Sterilizer, Fig. 29. The sterilizer was covered with heavy canvas during use. Beds G and H were each 30 feet long, and together they contained 696 plants. The soil was heated to 90 to 95 C., in less than 10 minutes, and that temperature maintained for thirty minutes. Of the 696 plants, 33 or 4.8 per cent. showed the disease, and again considerably more than in the control.

Experiment 4. To test the efficacy of top dressing with disinfected soil. The ends of three separate beds, C, B, and E, were used because these were more convenient to the steam connection with the boiler house.

A box was made 2 x 6 x 4 feet, thus capable of holding 48 cubic feet of soil. Soil was skimmed from the surface of the three beds; to a depth of one inch from E, of two inches from D, and of 3 inches from C, making in all a total of 150 cubic feet or approximately three times the box full. Soil was placed in the box to half fill it, then a system of drain tile was laid upon this soil and enough more soil was placed upon the tile to fill the box. Steam was turned on through the inlet, the ends of the drain tile being stopped with cement. The soil was heated to 90 degrees C. and kept at that temperature for one hour. This soil, after heating, was then scattered over the beds from which it had been taken and the disinfecting box filled again. Care was taken to sterilize the shovels each time after unsterilized soil had been handled with them.

The results of this top dressing of the beds is shown in the following table.

TABLE XVI.—SHOWING EFFECT OF TOP DRESSING WITH STEAMED SOIL.

Bed	No. of Plants in Bed.	Healthy Plants	Diseased Plants	Percentage of Disease	Depth of Top Dressing
E	320	399	21	7.02	1 inch
D	320	304	16	5.26	2 inches
C	320	308	12	3.89	3 inches

It is seen that the disease decreased with the increase in depth of the disinfected top dressing.

Experiment 5. To determine the effect of carbon bisulphide, one litre per square metre. One-half of Bed F was treated with carbon bisulphide, and covered with canvas for forty-eight hours, then the canvas was removed and the bed left open. No plants were set until the odor of the carbon bisulphide in the soil had disappeared.

At the time of harvesting the crop there had appeared in the bed 8 diseased plants in a possible 160, which is a slightly smaller per cent. than occurred upon the bed that was top dressed one inch deep. While this treatment seemed to check the disease somewhat it can not be regarded as satisfactory.

Experiment 10. To determine the effect of formalin 1 part to 400 parts of water.

Upon a bed fifteen long formalin of the above strength was sprinkled with a watering pot at the rate of one-half gallon to the square foot. One-half of this solution was applied at one time and the second half two hours later. After sprinkling the bed was left 2 days then stirred with a sterile hoe to aid in drying. Two days later the plants were set out. At harvest time the plants looked better, were more uniform in size, and there were no diseased plants among 160 that the bed contained. The treatment looked promising and the experiment was repeated at West Raleigh in 1908-09, with the result, however, that 62.5 per cent. of the plants were affected.

TABLE XVII.—SHOWING EFFECTS OF SOIL DISINFECTION.

Method	Number of Plants Treated	Diseased Plants in Treated Area	Healthy Plants in Treated Area.	Per Cent of Diseased Plants
Steamed with Drain Tile	1,260	88	1,172	6.98
Steamed with Sargent Sterilizer	696	33	663	4.80
Top Dressed with 1 in. Disinfected Soil	320	21	299	7.02
Top Dressed with 2 ins. Disinfected Soil	320	16	304	5.26
Top Dressed with 3 ins. Disinfected Soil	320	12	308	3.89
Sprinkled with Carbon Bisulphide	160	8	152	5.00
Sprinkled with Formalin at New Bern	160		160	
Sprinkled with Formalin at West Raleigh	144	90	54	62.50
Control	1,260	38	1,222	3.02

From the above experiments in attempts at soil disinfection little hope is to be had. Though these means of disinfection may apply well in green-house conditions, it is obvious that they are not satisfactory in extensive cold frames. Whether some other method of soil treatment may not be devised, we can not, of course, say. Theoretically, it seems possible, but that these means mentioned above are of practical service, seems very doubtful.

Practical Considerations.

The rational method of eradication of this pest based upon the facts here adduced would seem to be the same as that practiced against an annual plant, which if not allowed to produce new seeds will eventually, upon the growth of all old seeds, be brought to the end of its existence.

Sclerotia are not formed in diseased plants until the nutriment in the part affected is consumed, that is not until the plant has given clear easily discerned evidence of the presence of the parasite. If all such plants be pulled and burned no sclerotia will be made. The few small roots remaining in the ground will not usually be affected at this stage and even if they are, the formation of sclerotia in the roots under the ground is not common. This practice of constant removal of the sclerotinized plants will prevent the formation of new sclerotia and in course of time the sclerotia already present in the soil will have either decayed or germinated and thus become harmless. As an additional precaution it is well to kill all mycelium which may be left in the locus of the removed plant by a liberal application of some disinfectant such as copper sulphate. It appears that this line of treatment is the most promising in cases where the destruction of the sclerotia by steam is not practicable.

Since the ascospores are harmless except through the threshold of dead organic matter upon which to begin growth as saprophytes the careful removal from the bed of all torn, injured, sick or dead lettuce leaves should be practiced and manure and organic matter of other kinds had best be removed from the surface of the beds in the neighborhood of plants or covered so as to remove them from ascosporic infection. Similarly any injury to the plants as tearing the leaves, etc., which would result in dead bits of leaf, should be scrupulously guarded against.

Since frequent stirring of the soil inhibits production of ascospores it will be well to rake over the top soil to a depth of a half-inch once each week.

The above methods are of general application either in field or greenhouse. In addition to this soil disinfection, though it has not proved practicable in field or under canvas, is of great value under glass.

Botrytis and Sclerotinia.

Some species of Sclerotinia are genetically connected with Botrytis as a conidial form, notably:

Sclerotinia fuckeliana has as conidial form *Botrytis cinerea* Pers.

Sclerotinia vaccinii has as conidial form a Monilia.

Sclerotinia cinerea Sch. has as conidial form *Monilia cinerea Bon.*

These facts together with the sometime association or botryose and sclerotiniose upon the same plant very naturally led to the assumption that the Botrytis of the lettuce sustained genetic connection with Sclerotinia libertiana upon the lettuce.

Conflicting views have been held upon this point. Thus DeBary[23] as early as 1886 held that *Sclerotinia limertiana* had no true conidial form while some other species of the genus did produce Botrytis conidia. Humphrey[5] of the Massachusetts Agricultural Experiment Station says that the rotting of lettuce is due to *Botrytis vulgaris* Fr. which "is with little doubt the conidial stage of some sclerotium producing Peziza (Sclerotinia)." Stone and Smith[8] of the same station accepted this conclusion, but in 1898 and 1899 an extended study of *Sclerotinia libertiana* led them to believe that the Botrytis upon lettuce was not the conidial form of this Sclerotinia. Ramsey[13] of Wisconsin in 1904 considered the "drop" (Sclerotinia) as distinct from Botrytis. Hume[12] of Florida in 1901 believed this Sclerotinia to be entirely distinct from Botrytis.

Finally, Wulff,[24] also Westerdijk,[25] in recent papers upon these fungi, accept the conclusion that *Sclerotinio libertiana* has no Botrytis conidial stage.

Our experiments and observations bring out clearly the following facts:

1. That sclerotiniose may prevail in beds for months with its characteristic white mycelium with no accompaniment of botryose.

2. That botryose may similarly prevail in other beds with no accompaniments of sclerotiniose.

3. That in all of our cultures of these two fungi extending over an aggregate of some seven years, involving thousands of tube and plant inoculations, there has never occurred an instance of apparent change, in any way, from one of these forms to the other.

4. That the sclerotia of Sclerotinia differ in size and general appearance from those of Botrytis, and that in cases of botryose the sclerotia of Sclerotinia are not produced.

5. That the sclerotia of Botrytis invariably produce hyphæ and conidia upon germination, and that the sclerotia of Sclerotinia never do so.

6. That the sclerotia of Sclerotinia invariably produce ascospores, or at least abortive attempts to do so, while the sclerotia of Botrytis never do so.

We believe therefore that the evidence is sufficient to warrant the conclusion that these two fungi and the diseases caused by them are distinct and that one bears no present relation to the other, whatever their phylogenetic relation may be.

PART II.*

A Practical Test of a Curative Treatment.

The conclusions as recorded above, deduced from several years of laboratory and field study of this disease, especially those conclusions which point to the sclerotia as the only means of hibernation, began to force themselves upon the mind of the senior author some years ago.

Those conclusions seemed to be so unavoidable and their logical effect upon horticultural practice so fundamental and so significant that it was deemed imperative to put the question to a crucial test. If the theory as enunciated be true, all that is necessary in order to rid a Sclerotinia-infected lettuce bed of its pest is to prevent the formation of new sclerotia in it for a period of two or perhaps three years.

To make such a test the first essential was a bed thoroughly and unquestionably infected and so located and managed that it would not be subject to aerial or other extraneous infection.

The experimental lettuce beds of the Experiment Station located on the farm at West Raleigh are reasonably well isolated from any other infected beds which might furnish air-borne ascospores to bring about reinfection. Precaution could easily be taken to prevent access of sclerotia through manure or other sources. The beds are two in number, each 208 feet by 9 1-2 feet in size, 30 inches high on the north side, 8 inches on the south side, and are covered in the usual way by canvas supplemented when need be by burlap mats. They accommodate eight rows of plants, 77 plants to the row, with a total capacity, therefore, of 1,232 plants. The beds were to some extent infected owing to the nature of the experimental work that had been conducted in them. This infection was not, however, considered sufficient to make the test crucial.

The first step, therefore, was to thoroughly infect the beds and to demonstrate that they were so infected and to secure a record of the degree of infection. This was accomplished in the spring of 1908 by inoculating several rows or about 67 plants of the then large nearly mature marketable lettuce with Sclerotinia mycelium. Within a few days, April 18, the plants so inoculated all collapsed and followed the usual course of the disease. These plants and considerable other lettuce refuse as well were allowed to remain on the ground and since the plants were large the number of sclerotia that remained on the soil was very great. Thorough infection seemed sure. The lettuce was followed by cucumbers and in the autumn of 1908, October, the crop was put in in the usual commercial way and the record of disease for that year presented in Table XVIII and in Diagram I (Fig. 31), shows clearly that a full and thorough infection had been produced.

The plants, it will be seen, began to die of sclerotiniose in December and in January they were dying rapidly. The last record of disease

*Printed in part in an earlier Bulletin. (26.)

was on March 16, 1909. A total of 545 plants had died of sclerotiniose or over 45 per cent. of those in the beds.

To make records of disease the beds were inspected carefully each day and the cause of disease was determined by culture or microscopic examination or both, so that no doubt could exist on this point.

The work so far demonstrates thorough infection of the beds.

The second step of the test consisted in removing the plants before new sclerotia could form in order to determine whether by so doing the bed could in the course of a few years be freed from infection.

TABLE XVIII.—DAILY RECORDS OF DEATHS FROM SCLEROTINIOSE, 1908-1909.

Date	Number of Plants Diseased	Date	Number of Plants Diesased
Dec. 3	1	Jan. 2	3
5	2	4	9
14	1	8	10
20	2	11	41
24	2	13	29
11	21	15	12
18	2	17	10
20	11	20	24
21	2	24	73
22	8	26	94
23	2	Feb. 1	10
25	5	5	33
26	8	8	6
2	4	10	57
28	3	12	41
29	4	16	25
		Total	555

The daily inspection was most rigid. All suspected case of sclerotiniose were closely watched and as soon as the symptoms became reasonably indicative of this disease the plants, entire, were removed to the laboratory. *Thus no sclerotia were allowed to mature in the beds.* As an additional precaution the locus of the diseased plants were sprayed with a strong Bordeaux mixture.

The lettuce was followed by cucumbers and in the autumn, October 15, 1909, the next crop of lettuce was set.

It now remained to see whether the disease had increased, as it would have done under the usual modes of handling, or whether a decrease had been brought about by the hygienic treatment that had been followed.

The record of disease was kept precisely as in the preceding year and the same methods were taken to prevent maturity of sclerotia.

The record is presented in Table XIX and in Diagram II (Fig. 31).

TABLE XIX.—DAILY RECORDS OF DEATHS FROM SCLEROTINIOSE, 1909-1910.

Date		Number of Plants Diseased
Feb.	18	1
March	4	1
	22	1
	28	1
	31	2
	Total	7

It will be noted that no plants died of sclerotiniose prior to February 18, 1910, and none after March 31, and *that in all only seven plants or one-half of one per cent. of the crop died.*

This very large decrease in disease under one year of hygienic treatment—about 99 per cent. of the disease had been removed—was more than was anticipated and indicates even shorter life of the Sclerotia and greater loss of sclerotia from rotting than was predicated for them.

The beds were again set with lettuce in December, 1910.

This year approximately the usual number of plants, or to be exact, 1,113 in all, were set. The crop was raised to maturity, cut and sold. The record of disease is shown in Table XXI and in Diagram III (Fig. 31).

TABLE XX.—DAILY RECORDS OF DEATHS FROM SCLEROTINIOSE, 1910-1911.

Date		Number of Plants Diseased
April	18	1
	19	1
	20	3
	29	1
May	1	1
	15	1

Whatever may be thought of the theoretical questions involved, certain practical conclusions stand forth clearly and unmistakably.

1. The lettuce beds were very thoroughly infected. See record of 1908-09, Table XVIII and Diagram I.

2. Under usual conditions and usual mode of handling this disease would not have decreased but would have increased or at least remained destructive during following years.

3. Under the treatment that was followed, which had been indicated as the proper one by our laboratory and field studies, the disease decreased very markedly after one year and remained unimportant during the second year.

Whether the treatment employed here can be expected always to give such satisfactory results under all conditions of soil and climate can not of course be stated.

DIAGRAM I.

Winter, 1908-1909.

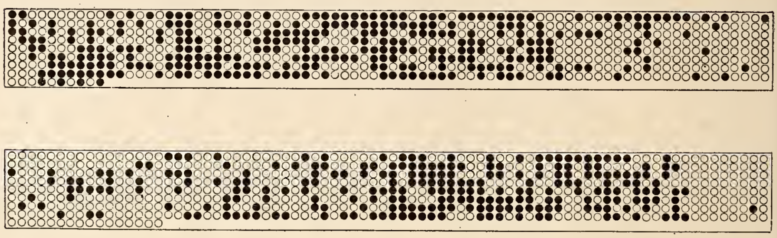


DIAGRAM II.

Winter, 1909-1910.

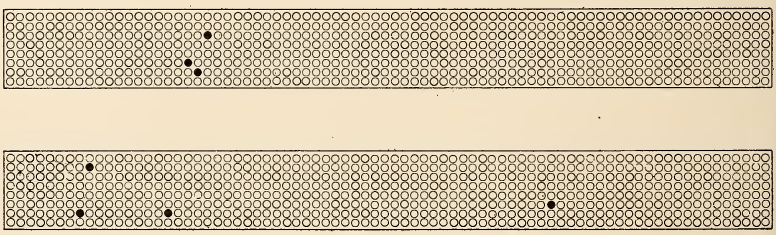


DIAGRAM III.

Winter, 1910-1911.

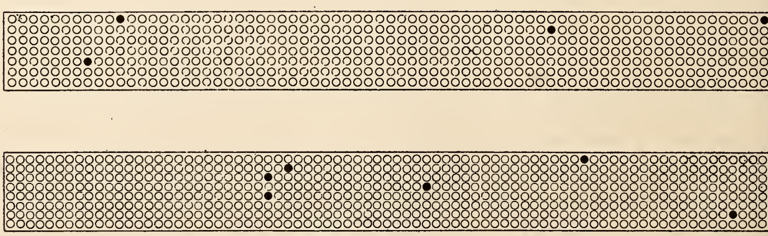


Figure 31.—Showing plan of Station beds and the exact location of affected plants in the bed during three seasons. • Diseased plant. o Healthy plant.

The writers feel justified, however, in stating that theoretically thi treatment should prove effective and that in the one extremely crucia test to which it has been submitted it has proved thoroughly effective They feel justified, therefore, in recommending it to lettuce grower who are troubled by this serious disease.

Recommendations.

The following recommendations for the treatment of beds infected with sclerotiniose are made.

1. The bed should be very carefully inspected every day and every plant that shows indications of this disease should be pulled up and burned.

2. The place in the bed from which sick plants are removed should be drenched with Bordeaux mixture or bluestone and water.

If these directions are followed no sclerotia will mature. The number of live sclerotia which will be present in the beds the following year will be very small and the amount of disease will be correspondingly reduced though it is not to be expected that the disease will be entirely eliminated. The next year the same treatment should be followed with just as much care as was given during the first year. Failure to be careful the second year will be fatal to success. It is probable that two years of this treatment will almost, if not quite, eradicate the disease. During later years, however, the beds should be watched closely and the same procedure followed. Beds which have been restored to a state of health and beds from which the disease has been partially eradicated should be protected from all possible sources of extraneous infection. It should be recognized that all refuse that comes from places where this disease exists is liable to bear the sclerotia and convey the disease. Therefore, all refuse from diseased lettuce beds, manure or fertilizer which may contain diseased refuse must be scrupulously avoided. There is also possibility of aerial infection. If infected beds exist nearby there appears to be no possibility of guarding against such infection and the method of treatment here advocated can not be expected to give its maximum of results if infected lettuce beds exist near the beds which are under treatment, since in such cases the danger of reinfection through the air will always be present.

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WEST RALEIGH

A SERIOUS LETTUCE DISEASE

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SUMMARY.

Lettuce Sclerotiniose, also known as "drop," "damp off," "wilt," etc., is the most destructive lettuce disease in North Carolina (page 8).

It is caused by a fungus (page 12), and is carried from season to season by small black bodies—Sclerotia—which thus serve as the "seeds" of disease (page 13).

Theoretically, if the formation of sclerotia can be prevented, an infected bed can be returned to health.

A practical test has shown how a badly diseased bed has been restored to health (page 16).

Directions for treatment of sick beds are given (page 17).

A SERIOUS LETTUCE DISEASE.

(*Lettuce Sclerotiniose.*)

By F. L. Stevens.[1]

Only a few years ago lettuce was regarded merely as a garden-grown plant for home consumption. It is now, however, an important article of commerce.

Fig. 1.—A lettuce plant suffering from sclerotiniose.

During the last decade there has been a large increase in the shipment from the South to metropolitan markets, particularly from North Carolina and South Carolina where lettuce is grown under cloth, and from Florida where it is grown largely in the open.

Wilmington was the pioneer lettuce-growing community of North Carolina, and the first lettuce raised under cloth for shipment in this State seems to have been grown by D. W. Trask, of Wilmington, about 1892. Three years before other commercial lettuce was produced in Wilmington, Mr. Trask, who raised lettuce in a small way for the

[1] J. G. Hall, former assistant, and G. W. Wilson, present assistant, aided in field work and in preparation of illustrations.

home market, had more than could be sold there and was forced to ship it. This lettuce sold at from $6 to $10 a barrel, and the area under

FIG. 2.—Lettuce growing under canvas and with irrigation at New Bern.

cloth was increased the next year to more than an acre. After the third year others began raising this profitable crop, and the area gradually increased until it aggregated between 75 and 100 acres under cloth.

Around New Bern lettuce was first grown for market in 1894.

At Fayetteville, commercial lettuce culture was apparently begun about 1895.

Considerable lettuce is also grown at Wilmington, Maxton, Willard, Raleigh, Faison, Wade, Tarboro, Chadbourn, Warsaw, Mt. Olive, and probably at other places in North Carolina.

Characteristic Symptoms of the Disease.

This disease may readily be distinguished from any other lettuce disease when the specific symptoms are once known.

Of these symptoms the one which first catches the eye of the lettuce grower is the rotting down of his plants in whole or in part. When first observed, a single leaf may be drooping, or wilting; a day or so later the whole plant is involved, the outer leaves dropping flat on the ground, the central head alone remaining standing. At this stage the plant appears as though scalded by an application of hot water. The head also soon succumbs to the rot and topples over. The first conspicuous symptom is this rotting and "dropping" of the whole plant.

Close examination of such rotting plants, especially in the later stages of the disease, reveals the presence of a delicate weft of cotton-like threads on the under side of the affected leaves, especially in the more moist regions, as at the base of the leaves near the stem. This

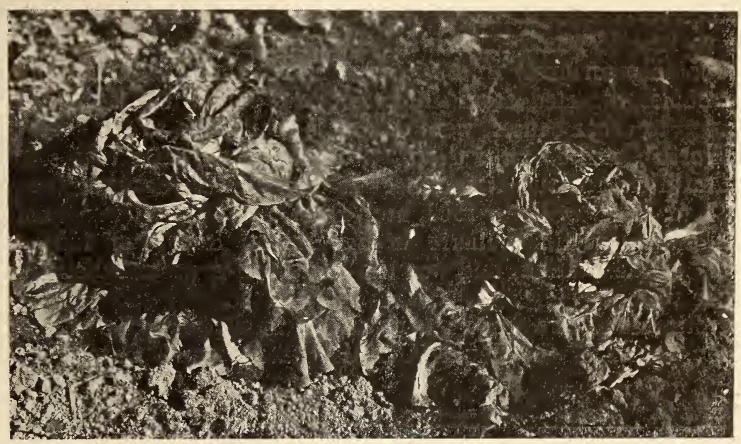

FIG. 3.—A diseased plant. Note wilt of the outer leaves.

character is limited to sclerotinoise, and is a sure indication of this disease.

In the last stages of the disease, a week or two after the final dropping of the plant, there will be found many small black bodies, sclerotia, varying in size from that of a pin head to a grain of corn, in or upon or under the sick portions of the plant. These, too, are absolutely characteristic of sclerotiniose.

These three characters—the dropping, the cotton-like mycelium, and the sclerotia—if carefully observed, enable any one to pronounce with certainty as to whether or not a given bed or plant is affected with sclerotiniose.

History of Sclerotiniose in America.

The disease characterized by the somptoms indicated above is termed *Sclerotiniose,* from the fungus *Sclerotinia,* which is its cause.

Since one of the chief symptoms of sclerotiniose, the symptom which certainly first catches the eye of practical lettuce growers, is a dropping and rotting of the outer leaves, followed usually by dropping and rotting of the rest of the plant, this disease has come to be called "the drop," by lettuce growers in many sections of the country. These symptoms may be produced by several different causes. "The drop" is, therefore, not one single definite disease. It is rather a condition or a symptom, just as lameness of horses is a condition or a symptom, not a disease. Lameness may be due to spavin, which is one disease, or to tuberculosis, which is another, etc. So "the drop" may be due to *Sclerotinia,* to *Pythium,* to *Botrytis,* etc., each of these causing a separate disease and each requiring different treatment according to the nature of the cause.

The first definite knowledge of the existence of lettuce *sclerotiniose* is contained in a communication by Smith, of Massachusetts, in 1900. The disease was then first clearly and accurately characterized and attributed to its causal fungus, *Sclerotinia libertiana.* While this date is the earliest of accurate knowledge concerning this disease, it was in all probability seriously injurious long before that time, and many lettuce troubles reported from different parts of the United States and attributed to other causes, were doubtless really due to it.

In North Carolina, "the drop," probably in all cases true sclerotiniose, first attracted the attention of lettuce growers around New Bern in 1897, at Fayetteville in 1901, at Warsaw in 1902. It was mentioned by the author of this bulletin in his Annual Report of 1907 to the Director of the Station, and was the subject of a press bulletin during the same year.

Sclerotiniose is now known to occur, as is shown in the accompanying map, in all of the South Atlantic States, North Carolina, South

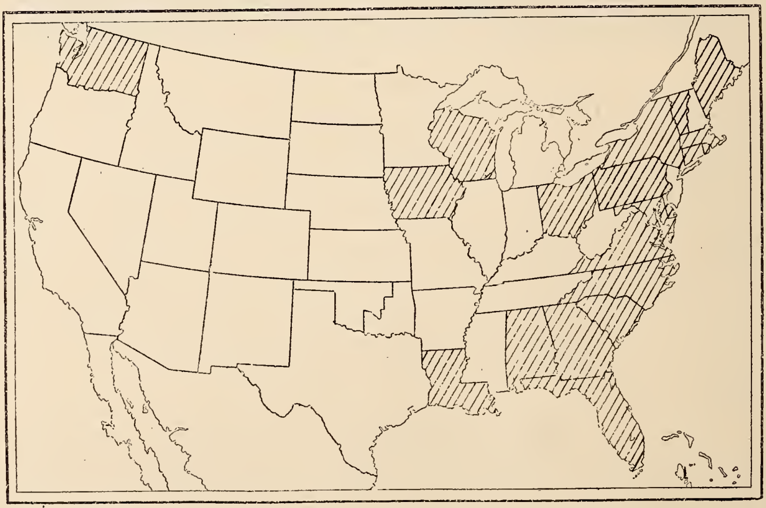

FIG. 4—States shaded are those in which sclerotiniose has been reported. It is not known to exist in others.

Carolina, Alabama, Georgia and Florida, and also in Louisiana, Massachusetts, New York, Ohio, Pennsylvania, Connecticut and Rhode Island, Wisconsin and Iowa, Washington, Vermont, Maine, Maryland, Deleware and Virginia. While not definitely recorded from other States, it probably occurs in many of them, particularly near the Atlantic seaboard.

From what is known of the disease, it is certain that it persists long and multiplies in territory once infected, and rapidly invades new regions. It is, therefore, increasing the area under its tribute yearly, nd will continue to become of wider significance, especially as the let-uce industry broadens.

Summarizing the history of sclerotiniose, it may be said to have at-racted attention first about 1890 in Massachusetts; in 1896 in Florida; n 1897 in North Carolina; in 1904 in Wisconsin; and to now possess ractically the whole Atlantic seaboard and some of the more Western tates.

Amount of Damage.

The extent of the damage varies with the severity of the epidemic nd with the value of the crop affected. In 1900, in Massachusetts, tone and Smith placed the proportion of plants succumbing to the dis-ase at from 15 to 85 or 95 per cent of the crop. They say: "The lat-er percentages are very exceptional, as growers are not content to ex-erience this loss more than once without making radical changes in heir methods. Practically entire crops have been destroyed by drop lone, to our knowledge, and the majority of growers in Massachusetts ave experienced at one time or another a loss of from 15 to 40 per ent. The loss of 25 per cent from drop is no uncommon experience in large number of lettuce houses, and when we consider that these ouses each may contain from 6,000 to 12,000 plants, worth from 0 cents to $1 per dozen, some idea of the loss may be obtained."

In Florida the loss is very severe, being sometimes complete.

In South Carolina whole crops are frequently destroyed and the let-uce industry seriously threatened, as is shown in the following quota-ion from a personal letter: "Several years ago I grew lettuce quite xtensively for Northern markets, but had to give it up on account of he damping off. * * * Lettuce is not grown here as extensively s in former years, principally on account of this disease."

In Maryland, sclerotiniose does damage in many greenhouses.

In Alabama, sclerotiniose is reported by Wilcox to do much damage n those places where lettuce is grown on a large scale. In Auburn nd Montgomery it is repeatedly met, with great loss.

In New York, some growers, says Stewart, "have had considerable rouble with the drop. It certainly is one of the troublesome diseases f lettuce." Whetzel, of the same State, says: "It (the drop) occurs nore or less commonly in all greenhouses about this State and some-imes in lettuce fields."

Damage in North Carolina.

In North Carolina this disease now shows itself to greater or less xtent at New Bern, Wilmington, Maxton, Fayetteville, Willard, Ra-eigh, and probably at numerous localities where lettuce is of less im-ortance. The damage done by it in 1906 is variously estimated at 0 per cent, 20 per cent, 33 per cent, 50 per cent, and 70 per cent, by lifferent growers. At Fayetteville the damage from this disease was stimated at from 10 to 50 per cent of the total value of the crop. Around Wilmington the loss was placed at 10 per cent. At New Bern stimates varied from 33 1-3 per cent to 50 per cent, while at Maxton he loss was placed at 20 per cent.

The disease sometimes appears the first season the crop is grown in a given soil, often not until many crops have been raised. When once it does gain a foothold in a bed it persists, multiplies and increases, until usually the grower is forced to move the bed to new regions, often to very soon meet again a similar fate. Thus the loss to the crop is coupled with the loss attendant upon moving the lettuce bed and frames, irrigation and heating pipes to new land, and the leaving of the enriched soil to go to a newer and poorer one.

Cursory Description of the Causal Fungus.

The cause of sclerotiniose is a fungus belonging to the genus *Sclerotinia,* a genus which is well known on account of its many destructive species, among them being two that are particularly conspicuous, one causing a serious and widespread apple rot and the other causing one of the worst of peach diseases. The fungus is known technically as *Sclerotinia libertiana* Fuckel. It was first described in 1869, and bears its present name, libertiana, in honor of Marie Anne Libert, who published on parasitic fungi from 1813 to 1837. The plant body of this fungus consists of delicate branching, mold-like threads called the mycelium, which may, with the microscope, or, if abundant, with the naked eye, be seen in or on the affected parts of the lettuce plant. No diseased part is free from them, and they are, on the other hand, never present without being accompanied by a condition of disease. It has been definitely proved beyond all doubt that these fungous threads are the actual cause of the disease, and that nothing else can cause this disease.

This fungous mycelium, coming in contact with a lettuce leaf, exudes a poison which kills the nearby cells of the lettuce plant. The cell walls are then dissolved and the mycelium makes its way through or between them. It dissolves also the contents of the cells, and absorbs the resulting nutrient solutions to further its own development. The mycelium thus grows larger, kills more cells, consumes them and continues to advance rapidly through the affected leaf, until the whole leaf is a soft, slimy, rotten mass. The invasion continues into the main stem, then upward to the central bud and "heart" of the head, out into other leaves, downward through the root, until every portion of the plant has been killed and the nutritious parts consumed.

Environmental conditions may, to some extent, change the course of the disease. The fungus grows best in abundant moisture. Sometimes this leads to a more rapid decay of the inner protected portion of the head, and a plant which, to casual inspection, appears healthy may prove upon close examination to be, at heart, a slimy, rotten mass. Again, through one-sided infection the decay may progress much more rapidly upon one side than upon another, resulting in complete death of one side before the other shows any symptom of disease.

As a rule the mycelium is not visible to the naked eye on leaves until the nutriment within the leaves has been nearly or quite exhausted by the fungus. When this time is reached the mycelium begins its external appearance as the loose, cottony growth referred to above. The most profuse development of this aerial mycelium occurs in the region f more humid atmosphere, such, for example, as on the under side of eaves lying upon the ground, between leaves, or at the base of leaves; n fact, anywhere that the air is so situated as to cause it to remain specially damp.

Soon after the appearance of the aerial mycelium in profuse quantity, t may be noted that in each region where the mycelium is dense there ppear one or more centers of aggregation, composed of very densely

FIG. 5—Sclerotia of various sizes, natural size.

ntertangled and interwoven mycelial threads. These denser masses nlarge, increase in density and finally become solid masses of tightly ompacted mycelium. The resulting bodies are called *sclerotia*. The

FIG. 6—Germinating sclerotia showing the stalks arising from them and the discs borne on the stalks.

sclerotia are at first colorless, then pale salmon color, and finally black on their exterior and flesh colored within. When first formed they are buried in and covered by mycelium, and are only to be seen by tearing this mycelial covering away. As time passes this mycelium is lost, the remains of the lettuce plant disappear, and the only visible evidence of the plant or the fungus is the sclerotia, many of which are produced in each sick plant.

The sclerotium germinates under suitable conditions, usually after a lapse of several months to nearly a year under field conditions. This it does by sending forth several thread-like sprouts about one-thirty-second of an inch in thickness. These sprouts expand at the end, developing a horn-like or cornucopia-like disk called the *apothecium*. This disk is, in the field, borne just at the surface of the ground with its face directed upward.

Microscopic examination of the disk shows it to consist of two parts: (1) lower basal part, supporting (2) an upper layer which consists of very numerous small, slender tubular bags or sacs (asci) which bear the spores of the fungus.

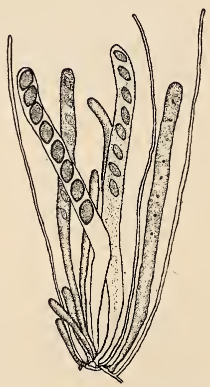

Fig. 7—Asci in which the spores are borne.

It is seen, then, that the disk is essentially an organ whose function is to produce myriads of spores.

When ripe, these spores are ejected from the sacs by pressure, being forced into the air often to a distance of several feet, where, caught by air currents, they may be carried quickly for great distances. The spores, under suitable surroundings, germinate and send forth small thread-like sprouts.

The sprout, with suitable nourishing material, grows rapidly into a vigorous mycelium, which is again ready to invade the living lettuce plant, to again cause disease.

This history of the drop fungus may be epitomized by saying that the mycelium grows within the lettuce plant, causing the disease; produces sclerotia when nutriment is exhausted; rests in the sclerotial condition until opportune conditions prevail; the sclerotia then produce disks bearing sacs in which are spores; these spores produce a new mycelium which again invades lettuce plants.

The Sclerotia.

Careful count was made of the number of sclerotia upon various parts of affected lettuce plants. The results are given below:

Plant No.	On Ground	In Axils of Leaves	Among Leaves	On Ground in Root	Total
1	-------------	9	2	1	12
2	-------------	9	-------------	2	11
3	-------------	9	-------------	-------------	9
4	1	14	8	10	33
5	-------------	9	1	4	14
6	-------------	13	2	4	19
7	-------------	8	14	4	26
8	-------------	23	1	-------------	24
9	-------------	10	-------------	4	14
10	-------------	9	-------------	-------------	9
Total-------	1	113	28	29	171
Average----	1	11.3	2.8	2.9	17.1

These plants from which these records were taken were naturally infected in the lettuce beds. It is seen that the greatest number of sclerotia was formed in the axils of the leaves around the stem. Those formed in the ground on the root were produced only after the root had begun to decay. No plants that were examined, in which the roots had not begun to decay, showed signs of sclerotia below ground, and in very few instances was there any external sign of the fungus in the parts below ground.

If half of a bed of ordinary size, 9 by 200 feet, bearing 2,000 plants, be diseased, it is seen that there may be formed as many as 17,100 sclerotia per bed. It is quite certain that this estimate does not fully represent the actual number formed under conditions of badly infected beds. Estimate has further shown that one sclerotium may on the average produce 10 disks and that each disk can produce about 31,000,000 spores. The number of spores, each potentially an infecting agent, that can come from an infected bed is seen to be something stupendous.

General Relations of the Fungus in Nature.

It is definitely known that the fungus which actually causes this disease, propagates and spreads by means of its spores which are produced from the germinated sclerotia and by its mycelium.

It has been found by long laboratory and field study that the spores are comparatively short-lived even under the conditions most favorable to their longevity. In condition of nature, subject to alternate dryness and atmospheric humidity, they would invariably germinate and in the absence of favorable nutrient pabulum they would die. Thus the spores can not function to any large degree as a means of carrying this fungus over periods of time of any considerable duration.

The mycelium has also been shown to be of comparatively short life and to retain its infecting power but a short time in the absence of nutriment. This, too, can not be regarded as a means of carrying the fungus over long time intervals. Any possibility that the mycelium may remain alive in soil that has borne sclerotinised plants is very remote, probably nonexistent. *The sclerotium is long-lived and well adapted to perpetuate the fungus. It alone of all the structures of the fungus is able to live for sufficiently long periods to bridge over seasons adverse to the growth of the fungus* or long periods of time when no food is available.

The fungus may, therefore, be likened to an annual plant all parts of which, except the seed, die at the approach of winter, the sclerotium in this instance acting the role of the seed.

The sclerotia rest during the period of inactivity of the disease; that is, from the harvest of one lettuce crop until the next crop is present under suitable weather conditions, to permit of infection. They then germinate, and produce disks with a crop of myriads of spores.

Attempts to Control.

Lettuce sclerotiniose some years ago became so bad in greenhouses in Massachusetts that many growers lost practically their whole crop from this cause. Disinfection of the soil, however, proved a practicable remedy under greenhouse conditions.

The two principal methods of soil disinfection early used were (1) by means of chemical solutions, and (2) by means of heat. The first of these has proved to be unsatisfactory and impractical in most cases. The second has been of very great benefit.

One of the earlier methods for heating the soil was to sprinkle it with hot water. This was of some value but not entirely effective, and moreover, it possessed the disadvantage that it left the bed so wet that it had to remain idle for considerable time in order to become dry enough to work.

The substitution of steam heat as a disinfectant followed, and it is today used with considerable success under greenhouse conditions.

The disinfection of greenhouse soil in one way or another has been used in Rhode Island, Vermont, Ohio, and some other States, nearly always with beneficial results.

In Kentucky, a drop disease is reported to have been checked by sub-irrigating and placing a mulch of excelsior under the plants to prevent their touching the soil.

Numerous experiments conducted by the writer, mainly on commercial beds at New Bern, with various methods of soil sterilization, including tile drainage and steaming, steaming with a Sargent sterilizer, top-dressing with disinfected soil to various depths, drenching with carbon disulphide, and also with formalin, all failed to show any promise of being satisfactory means of eliminating this disease under our open-bed conditions.

A Treatment That Proved Effective for Open Beds.

The conclusions as recorded above, deduced from several years of laboratory and field study of this disease, especially those conclusions which point to the sclerotia as the only resting stage of the fungus, began to force themselves upon the mind of the writer several years ago. Those conclusions seemed to be so unavoidable and their logical effect upon horticultural practice so fundamental and so significant that it was deemed imperative to put the question to a crucial test. If the theory as enunciated on page 14 be true, all that is necessary in order to rid a sclerotinia-infected lettuce bed of its pest is to prevent the formation of new sclerotia in it for a period of two or perhaps three years. To make such a test the first essential was a bed thoroughly and unquestionably infected and so located and managed that it would not be subject to aerial or other extraneous infection.

The experimental lettuce beds of the Experiment Station, located on the farm at West Raleigh, are reasonably well isolated from any other infected beds which might furnish air-borne spores to bring about reinfection. Precaution could easily be taken to prevent access of sclerotia through manure or other sources. The beds are two in number, each 73 feet by 8 feet in size, 30 inches high on the north side, 8 inches on the south side, and are covered in the usual way by canvas, supplemented when need be by burlap mats. They accommodate eight rows of plants, 77 plants to the row, with a total capacity, therefore, of 1,232 plants. The beds were already to some extent infected, owing to the nature of the experimental work that had been conducted in them. This infection was not, however, considered sufficient to make the test crucial.

The first step, therefore, was to thoroughly infect the beds and to demonstrate that they were so infected and to secure a record of the degree of infection. This was accomplished in the spring of 1908 by inoculating several rows, about 67 plants, of the then large, nearly mature marketable lettuce plants with sclerotinia mycelium. Within a few days, April 18, 1908, the plants so inoculated all collapsed and followed the usual course of the disease. These plants, and considerable other lettuce refuse as well, were allowed to remain on the ground, and since the plants were large, the number of sclerotia that remained on the soil was much above the average for sick plants. Thorough infection seemed sure. The lettuce was followed by cucumbers and in October, 1908, the crop was put in in the usual commercial way. The record of disease for that year, presented in Table I and in Fig. 8, shows clearly that a full and thorough infection had been produced.

TABLE I—DAILY RECORDS OF DEATHS FROM SCLEROTINIOSE IN 1908-1909.

Date.	Number of Plants Diseased.
Dec. 3	1
5	2
14	1
20	2
24	2
Jan. 11	21
18	2
20	11
21	2
22	8
23	2
25	5
26	8
27	4
28	3
29	4
Feb. 2	3
4	9
8	10
11	41
13	29
15	12
17	10
20	24
24	73
26	94
Mar. 1	10
5	33
8	6
10	57
12	41
16	25
Total	555

The plants, it will be seen, began to die of sclerotiniose in Decem and in January they were dying very rapidly. The last record of ease was on March 16, 1909. A total of 555 plants had died of disease, or over 45 per cent of those in the beds.

To make records of disease the beds were inspected carefully each day and the cause of disease was determined by culture or microscopic examination, or both, so that no doubt could exist on this point.

The work so far demonstrated the thorough infection of the beds.

The second step of the test consisted in removing the plants before new sclerotia could form, in order to determine whether by so doing the bed could in the course of a few years be freed from infection.

The daily inspection was most rigid. All suspected cases of sclerotiniose were closely watched, and as soon as the symptoms became reasonably indicative of this disease, the plants, entire, were removed to the laboratory. Thus no sclerotia were allowed to mature in the beds. As an additional precaution the locus of the diseased plant was sprayed with a strong Bordeaux mixture.

The lettuce was followed by cucumbers, and in the autumn (October 15, 1909) the next crop of lettuce was set.

It now remained to see whether the disease had increased, as it would have done under the usual modes of handling, or whether a decrease had been brought about by the theoretically hygienic treatment that had been followed.

The record of disease was kept precisely as during the preceding year and the same methods were taken to prevent maturity of sclerotia.

The record is presented in Table II and in Fig. 8.

TABLE II—DAILY RECORDS OF DEATHS FROM SCLEROTINIOSE IN 1909-1910.

Date.		Number of Plants Diseased.
February	18	1
March	4	1
	7	1
	22	1
	28	1
	31	2
Total		7

It will be noted that no plants died of sclerotiniose prior to February 18, and none after March 31, 1910, and that in all only seven plants, or one-half of one per cent of the crop, died.

This very large decrease in disease under one year of hygienic treatment (about 99 per cent of the disease had been removed), was more than was anticipated and indicates even shorter life of the sclerotia and greater loss of sclerotia from rotting than was predicted for them.

The beds were again set with lettuce in December, 1910.

This year approximately the usual number of plants, or, to be exact, ,113 in all, were set. The crop was raised to maturity, cut, and sold. This year only 9 plants died during the whole season.

Whatever may be thought of the theoretical questions involved, certain practical conclusions stand forth clearly and unmistakably:

1. The lettuce beds were very thoroughly infected (see record of 1908-09, Table I and Fig. 8).

2. Under usual conditions and usual mode of handling, this disease would not have decreased but would surely have increased, or at least remained destructive during following years.

3. Under the treatment that was followed, which had been indicated as the proper one by our laboratory and field studies, the disease decreased to an entirely negligible quantity after one year and remained unimportant through all the next year.

Whether the treatment employed here can be expected always to give such satisfactory results under all conditions of soil and climate, can not, of course, be stated.

The writer feels justified, however, in stating that theoretically this treatment should prove effective and that in the one extremely crucial test to which it has been submitted it has proved thoroughly effective. He feels justified, therefore, in recommending it to lettuce growers who are troubled by this serious disease.

Recommendations.

The following recommendations for the treatment of beds infected with sclerotiniose are made:

1. The bed should be very carefully inspected every other day and every plant that shows indications of this disease should be pulled up and burned.

2. The place in the bed from which sick plants are removed should be drenched with Bordeaux mixture or bluestone and water (1 pound to 7 gallons). If these directions are followed, no sclerotia will mature. The number of live sclerotia which will be present in the beds the following year will be very small and the amount of disease will be correspondingly reduced, though it is not to be expected that the disease will be entirely eliminated.

3. The next year the same treatment should be followed with just as much care as was given during the first year. Failure to be careful the second year would be fatal to success.

It is probable that two years of this treatment will almost, if not quite, eradicate the disease. During later years, however, the beds should be watched closely and the same procedure followed.

Beds which have been restored to a state of health and beds from which the disease has been partially eradicated should be protected from all sources of extraneous infection. It should be recognized that all refuse that comes from places where this disease exists is liable to bear the sclerotia and convey the disease. Therefore, all refuse from diseased lettuce beds, manure which may contain diseased refuse, must be scrupulously avoided. There is also possibility of aerial infection if infected beds exist nearby. There appears to be no possibility of guarding against such infection, and the method of treatment here advocated can not be expected to give its maximum of results, if infected lettuce beds exist near the beds which are under treatment, since in such cases the danger of reinfection through the air will always be present.

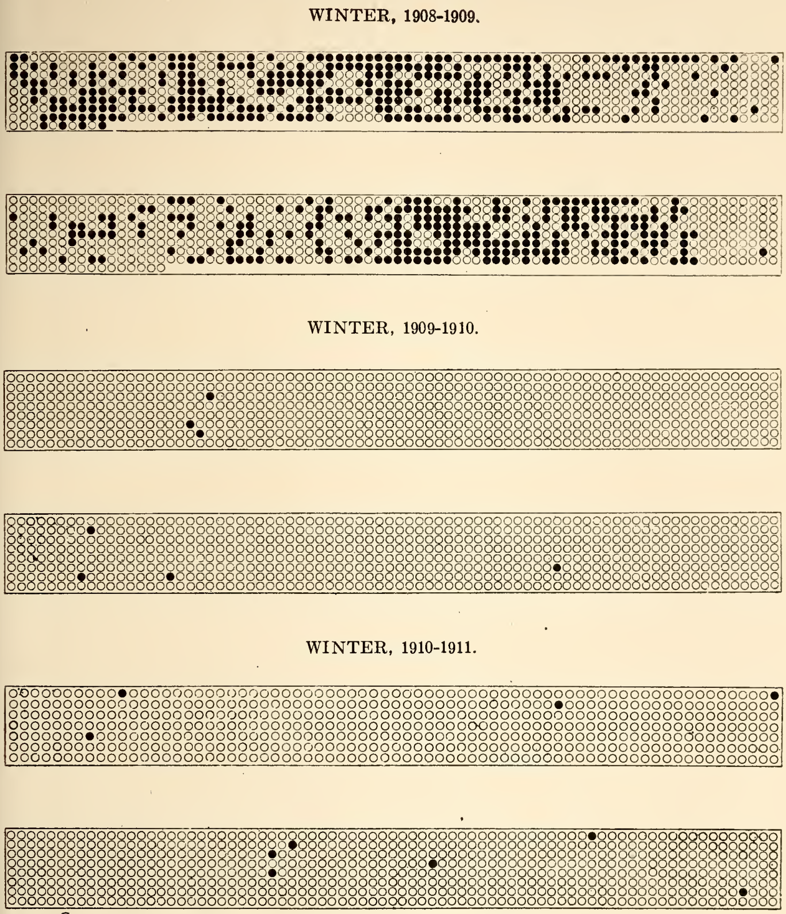

FIGURE 8. Showing plan of Station beds and the exact location of affected plants in the bed during three seasons. ● Diseased plant. ○ Healthy plant.

[illegible]

BULLETIN 218 JULY, 1911

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

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THE NORTH CAROLINA

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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SUMMARY.

The feeding of beef cattle can be made profitable in this State, especially dur-g the winter months. While large profits can not be obtained usually, the in-istry furnishes a means of using the cheaper rough feeds on the farm and ob-iining the feeding value of cottonseed meal before it is used as a fertilizer.

The length of the feeding period is limited because of the harmful effect of ttonseed meal when fed in quantities sufficient to produce large gains. The ost profitable feeding period will range from one hundred to one hundred and venty days, the exact length of time depending upon the amount of cottonseed eal fed daily.

The average daily feed of cottonseed meal for two and three year old steers ould be about seven pounds per animal. The average daily feed used in these :periments, including the preliminary period, was 7.30 pounds per animal the st year and 6.82 pounds the second year.

The average amount of cottonseed meal fed during the two years to produce a und of gain was 5.71 pounds for lot 1, fed corn silage and corn stover for ughage; 5.77 pounds for lot 2, fed corn silage for roughage; and 5.17 pounds r lot 3, fed cottonseed hulls for roughage. These figures show that it took less ttonseed meal to produce a pound of gain when fed with cottonseed hulls than hen fed with either corn silage or corn stover.

The average daily gain for the two years was largest with the steers fed cot-nseed meal and cottonseed hulls. The average daily gains made by the steers d cottonseed meal, corn stover and corn silage, and cottonseed meal and corn age were approximately the same each year.

The cheapest gains were made the first year by the steers fed cottonseed eal and corn silage. In the second year the steers fed this ration made cheaper ins than any of the others, either the first or second year of the experiment. le cost of gain should not be confused with the final profits, which are influ-ced by the quality of the steers and the selling price per pound.

The second cheapest gains during the first year were made by the steers fed ttonseed meal and cottonseed hulls and during the second year by those fed ttonseed meal and corn silage. The most expensive gains were made both ars by the steers fed cottonseed meal, corn silage and corn stover.

While the steers fed cottonseed meal and cottonseed hulls made somewhat rger and cheaper gains during the second year, their dressing percentage was o and one-tenth per cent lower than the steers fed cottonseed meal and corn age, and two and two-tenths per cent lower than the dressing percentage of e steers fed cottonseed meal, corn silage and corn stover.

The parties handling these steers reported them much better as a whole than ost of those sold on the local market. The special criticism made, however, is that the steers fed cottonseed meal and cottonseed hulls were inferior in tting qualities to either of the other two lots.

The cost of the gains was rather high with all the steers both years; however, e gains made by the feeders of this State in general will usually cost as much

or more. The high cost of gains on the experimental cattle was partially th result of using a grade of steers inferior in breeding and gaining qualities al though the cattle as a whole were better than the average grade of cattle fe in the State. High grade feeders properly fed should make double the gain made by these steers, which would reduce the cost of gains one-half.

The average cost of the gains per hundred pounds for the two years was $17.5 for lot 1, $15.56 for lot 2, and $15.13 for lot 3.

The average profit per steer for the two years, including the manure, was $4.3 for lot 1, $7.99 for lot 2, and $4.44 for lot 3. These results show that cor silage is an excellent feed for fattening beef cattle. It not only made a large profit per steer but produced a better quality of meat than did the other feeds.

The average price per hundred pounds live weight necessary during the tw years to clear the total cost of the finished steers was $6.08 for lot 1, $5.78 fo lot 2, and $5.99 for lot 3. The average price actually obtained was $5.82 for lo 1, $5.87 for lot 2, and $5.73 for lot 3.

The cattle fed corn silage both years returned slightly more than necessary t balance the original cost of the steers and the feed consumed without consider ing the value of the manure. This was true with only one other lot o steers. During the first year, the cattle fed cottonseed meal and cottonseed hull returned just enough to balance the transaction without counting the value o the manure. In every other case there was a slight loss, although when th value of the manure was considered each lot made a satisfactory financia showing.

Steers intended for feeding purposes should be at least two years old an should weigh preferably 900 to 1,000 pounds in order to fatten satisfactoril in the short feeding period necessary when fed on cottonseed meal. This i especially true of cottonseed meal because of its high nitrogen content. A feed o this character when fed to immature animals will prolong their growing perio consequently the advantage of feeding heavier cattle which have reached ma turity.

As the results obtained in these experiments seem to favor the use of cor silage for fattening beef cattle, it is important that the feeder save a portion c his corn crop in the form of silage. It is not good business policy for th feeder to buy cottonseed hulls at the present prices to replace this roughag which can be produced on the farm; especially so when it is considered that i will give equal or better results than cottonseed hulls.

It is necessary to have a margin of $1.50 to $1.75 per hundred pounds liv weight to insure satisfactory financial returns on beef cattle. During the firs year the margin on the steers used in this experiment was $1.75 per hundre pounds and the second year $1.375 per hundred pounds.

FEEDING EXPERIMENTS WITH BEEF CATTLE

By R. S. Curtis.

Beef Cattle Industry of North Carolina.

The feeding of beef cattle in North Carolina will undoubtedly become an important industry. In the western portion of the State, the mountain pastures afford excellent grazing where already very desirable types of feeding cattle are being produced. With the advent of better bred sires to use on the common cattle of that region and the improvement of the pasture lands by better management the industry is sure to develop rapidly. Prominent cattle growers state that a large percentage of the desirable grazing land is not at present utilized for pasturage purposes. Not only will the area be extended into the more remote parts, but the quality of the pastures will be improved by better methods of management.

The writer mentions North Carolina especially because the western section of the State is typical of the Appalachian region for cattle grazing purposes. The production of feeding cattle is not limited to this State alone, as Virginia and Tennessee, especially, can produce types of cattle equally as desirable, and within reach of the cattle feeders of this State. Virginia is using to a large extent her own cattle for feeding purposes and also the larger and better cattle of eastern Tennessee and western North Carolina. This is a condition which should receive the attention of the more progressive stockmen of this State. North Carolina feeders should feed all of the cattle produced in the State and, if necessary, draw on the surrounding States for surplus needs.

It need not be stated that cottonseed meal is the only commercial concentrate which at present can be used for feeding beef cattle. The cattle feeding industry furnishes a means of obtaining both the feed and fertilizer values from this commercial product and for this reason every effort should be made to use as much cottonseed meal in our live stock and general farming industries as conservative business methods will permit. It has not been definitely determined just how much cottonseed meal is most profitable for feeding beef cattle, but it is likely that the concentrated portion of the ration will consist largely of cottonseed meal for an indefinite period. Knowing the approximate quantity of cottonseed meal which will form a safe and satisfactory ration, the writer has confined his work of the last two years in determining the most profitable roughage feeds to use with the meal.

The chief roughages available in this State are corn stover, corn silage, and cottonseed hulls. Others of local importance could be named, but it is considered that these three are the most important from the standpoint of economy in beef production. As beef cattle do not return large profits in the South it is necessary to confine the roughage part of the rations to the less valuable feeds produced on the farm.

These experiments are based upon the fact that large quantities of corn stover are wasted annually, that corn preserved as corn silage is the most economical method in saving the crop and that corn silage is rapidly coming into favor as a beef cattle feed. Cottonseed hulls, though recognized as important, are becoming more expensive each year, and from the evidence obtained at this Station and elsewhere they are not as satisfactory for roughage as corn stover or corn silage. It is not a judicious practice to use costly commercial feeds to replace corn silage and corn stover which can be produced on every farm.

Objects of Experiment.

The objects of the experiment were to determine the difference in the feeding value of corn stover, corn silage, and cottonseed hulls when fed with cottonseed meal. This determination included the following:

1. The average daily gains.
2. The quality of the carcass.
3. The economy of production.

The last factor is really the most important to the feeder, yet the quality of the carcass influences the selling price of cattle to a marked extent. This proved to be of special importance in this case.

Plan of Experiment.

The experiment was planned with the idea of making a comparison of corn stover, corn silage and cottonseed hulls as roughage feeds. The same quantity of cottonseed meal was fed to each of three lots of steers. When an increase was made for one lot, the same increase was made for each of the other two lots. The aim was to feed as much meal as possible for best results. Conditions were made as nearly the same for each lot of cattle as possible, the only variation being in the kind and quantity of roughage given.

Fig. 1—Station Beef-Cattle Barn.

In making an increase or changing the proportions of roughage feeds, due consideration was given the individual appetite of the steers, allowing them to direct rather than to follow any special scheme of feeding the roughage. At all times, however, judgment was used in withholding an undue increase of any part of the rations and especially was this true in the preliminary feeding period.

Barn Lots and Water Supply.

The steers were fed in the barn, shown in Fig. 1. The stalls were ocated on the south side and were fifteen feet wide by twenty feet long. They were connected with lots twenty feet wide by eighty feet long. The steers were kept in the stalls during the night and a large part of he day. Water was furnished from a supply tank. This system of lose housing was followed primarily for the purpose of conserving the nanure, otherwise the steers would have been given the free use of the ots. While the barn was closed on all sides, it was well ventilated so hat the steers always had comfortable and healthy surroundings. Bedling was supplied in the stalls and lots in quantities sufficient to retain he manure and keep the lots in a dry condition, which was sometimes lifficult during rainy weather.

Description of Steers.

The steers used in the experiments were purchased in western North Carolina, and were taken directly from the pasture and started on fattening feeds at the Station farm. They were fairly uniform in size and ype, averaging about nine hundred pounds in weight both years. They vere principally Shorthorn grades, although some showed traces of other blood. On the whole, they would class as average feeders in the Southern States. They were quite superior, however, to the general run of steers brought from the mountains by the farmer feeders in this State. The type of the steers used is shown in Figs. 2, 3, 4, 5, 7 and 9.

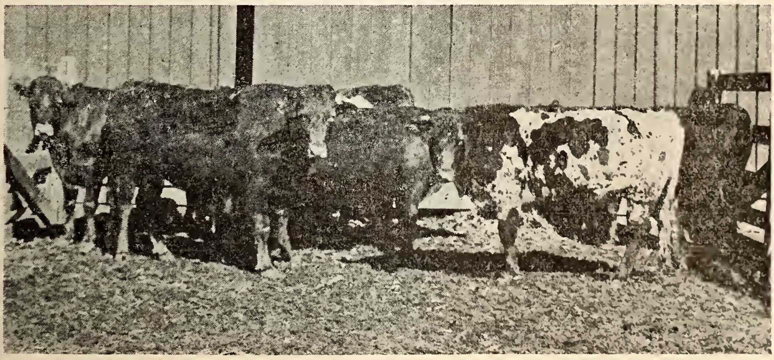

FIG. 2—Steers fed cottonseed meal, corn stover and corn silage in 1909-1910.

The first year the steers were somewhat heavier and on the whole they vere more uniform in size and type, however, the difference was not narked. One lot used the last year, averaged just one-half pound under nine hundred, while the other five lots averaged somewhat more. The size and type was as uniform as could be expected.

In making the division the steers were separated into three lots of quite uniform size, type and weight.

Weights of Steers.

During the experiment the steers were weighed each week about eight in the morning before any feed or water had been given. The initial weight for each lot was derived by taking the average of two weighings made on consecutive mornings. The final weights used were those taken by the buyer of the steers.

Shrinkage.

The average shrinkage on steers coming from the mountains of this State will be from seven to eight pounds per hundred pounds live weight. This will usually be regained in six to eight days as a large amount of the loss in weight is due to fill. The steers used in the experiments were allowed to regain their original weight before any experimental data were recorded.

Kind of Feeds Used.

The cottonseed meal used was the ordinary commercial product. No effort was made to secure a better grade of meal than is actually used by the farmer feeders. The only requirement regarding the meal was that it measure up to the standard required by the State.

The roughage feeds used consisted of corn stover, corn silage and cottonseed hulls. The quality of the corn stover and the corn silage was somewhat better during the second than the first year, while the cottonseed hulls were practically of the same grade both years. During the first year the corn stover was very dry and contained considerable dust, while the corn silage was inferior principally because of the small number of ears on it. In the second year, the corn stover was cured somewhat better, not being so dry and dusty; while the corn silage was superior principally because of the larger number of ears it contained.

In table 1 is shown the average composition of the feeds used in the experiment.

TABLE 1—SHOWING THE AVERAGE PERCENTAGE COMPOSITION OF FEEDS USED IN EXPERIMENT.

Feeds Used.	Water.	Dry Matter.	Ash.	Protein.	Carbohydrates.	Fat or Ether Extract.
Cottonseed meal[1]	8.0	92.0	6.5	41.1	35.4	9.0
Cottonseed hulls[2]	11.1	88.9	2.8	4.2	79.7	2.2
Corn stover[3]	40.5	59.5	3.4	3.8	51.2	1.1
Corn silage[4]	73.6	26.4	2.1	2.7	20.7	0.9

[1] North Carolina Experiment Station chart by C. B. Williams.
[2] Feeds and Feeding—Henry, page 567—tenth edition.
[3] Feeds and Feeding—Henry, page 568—tenth edition.
[4] Feeds and Feeding—Henry, page 572—tenth edition.

Valuation of Feeds.

The feeds used were rated per ton as follows: cottonseed meal $30.00, cottonseed hulls $8.00, corn silage $2.75, and corn stover $8.00.

The average price of cottonseed meal throughout the last two years has been about $30.00 per ton. Considering that neither the corn silage nor the corn stover were up to standard either year, the writer considers this a liberal estimate on these feed values.

Amount of Cottonseed Meal Fed.

While the average amount of cottonseed meal fed daily each year was about the same, as will be seen from table 2, the increase was not so rapid the first year as the second, and the total quantity fed during the last few weeks of the feeding period during the first year was greater than the amount fed during the corresponding period the second year. Practically the same amount of meal was fed per steer each year, but the distribution was different. In each case, however, the amount fed at first was very small, and gradually this was increased to a full ration. There was no evidence at any time during the feeding periods that the cottonseed meal had any detrimental effect on the steers unless it was the decreased gains which came toward the last. This, however, is a natural condition during the latter stages of fattening with all feeds, although it is true to a greater extent with cottonseed meal than with other feeds.

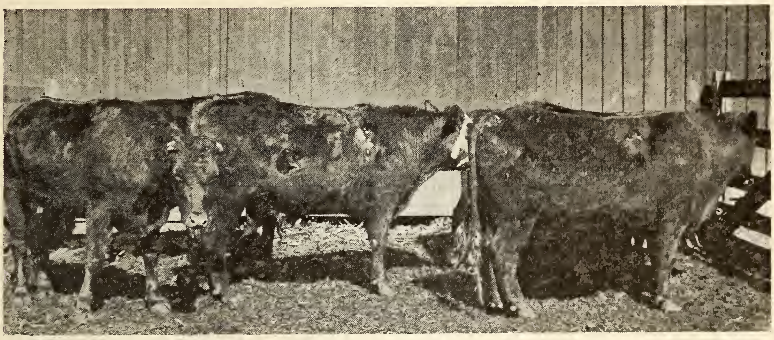

FIG. 3—Steers fed cottonseed meal and corn silage in 1909-1910.

The amount of cottonseed meal that may be fed most profitably will be discussed in a subsequent bulletin. The writer is working on this problem and considers it an important field for experimental work. In table 2 is shown the average amount of cottonseed meal which was fed daily to each of the steers in the three lots.

TABLE 2—SHOWING THE AVERAGE AMOUNT IN POUNDS OF COTTONSEED MEAL FED PER STEER BY MONTHS, INCLUDING THE PRELIMINARY PERIOD.

Periods.	In 1909–1910.			In 1910–1911.		
	Lot 1.	Lot 2.	Lot 3.	Lot 1.	Lot 2.	Lot 3.
First month	3.23	3.23	3.23	4.96	4.96	4.96
Second month	7.57	7.57	7.57	7.32	7.32	7.32
Third month	8.40	8.40	8.40	7.50	7.50	7.50
Fourth month	10.00	10.00	10.00	7.50	7.50	7.50
Average	7.30	7.30	7.30	6.82	6.82	6.82

Method of Feeding.

The steers were fed regularly twice each day, at seven in the morning and four in the afternoon, except on weighing days when they were fed somewhat later in the morning than usual. The corn silage for lots 1 and 2 was first put in the feed troughs and distributed uniformly, after which the cottonseed meal was spread over and thoroughly mixed with the silage. These rations were consumed very readily when prepared in this manner. It was quite noticeable that they were always eaten by the steers before they left the trough while the lot getting cottonseed hulls as roughage invariably left an appreciable quantity, returning later in the day to consume the remaining portion.

The corn stover for lot 1 was put in the feed racks after the meal and silage had been fed. Usually this was not all taken until quite late in the day, the steers eating it at liberty after the meal and silage had been consumed. Lot 2 received no dry roughage; however, the larger quantity of silage given seemed to satisfy the steers quite well. The cottonseed hulls fed to lot 3 were placed in the trough, and the cottonseed meal was then spread uniformly over the hulls and the two feeds thoroughly mixed. All the rations seemed to be very palatable, however this was especially true when silage formed part of the feed.

Fig. 4—Steers fed cottonseed meal and cottonseed hulls in 1909-1910.

In every case where there was a tendency to leave any of the rations, they were reduced until the quantity fed was taken readily. In this way the appetite of the steers was always kept keen. In table 3 is shown the average amount of each feed used per steer in the daily ration. Any one of these combinations forms a well balanced ration, as the feeds are all of such a composition that the shortage of a nutrient in one is balanced by an excess of this nutrient in the other. For example, cottonseed meal is high in protein and low in carbohydrates, while cottonseed hulls are low in protein and high in carbohydrates. The same condition is true with the other roughage feeds used in combination with cottonseed meal.

TABLE 3—SHOWING THE AVERAGE AMOUNT OF FEEDS USED IN THE DAILY RATION PER STEER DURING THE EXPERIMENT.

Feeds.	In 1909-1910.			In 1910-1911.		
	Lot 1.	Lot 2.	Lot 3.	Lot 1.	Lot 2.	Lot 3.
Cottonseed meal	8.14	8.14	8.14	6.77	6.77	6.77
Cottonseed hulls			17.92			21.60
Corn stover	16.52			20.80		
Corn silage	23.17	35.36		23.64	32.55	

The first year each steer in lot 2 was fed in addition to the regular ration 405 pounds of corn stover and in lot 3, 467.5 pounds of corn silage during the first twenty-five days of the experiment. This was done to overcome any detrimental effect in changing from succulent feeds to dry feeds or vice versa. This practice is not absolutely necessary, but to safeguard against getting the digestive system out of order it is not an unwise practice.

Preliminary Feeding.

Both years each of the three lots of cattle was given a short preliminary feeding period so that the experimental feeding did not start with the initial feeding period. The first year fourteen days were allowed for the steers to regain their normal condition. In the second year, however, only four days were allowed which was just sufficient for the steers to regain their original weight. During the preliminary period the steers were fed principally on roughages, such as corn stover, oat hay and a small amount of silage. A very small amount of corn and wheat bran was fed the first year. This was done principally to improve the appetite and give each lot of cattle the same chance when the experimental rations were started.

The cost of the preliminary feeding is not included in the experimental data showing the difference in the economy of each roughage. The financial statements are based on the final feeding period, and do not include the cost of the preliminary feeding.

Table 4 gives a summary of the important factors involved in the experiments during the two years.

TABLE 4—GIVING SUMMARY OF RESULTS DURING TWO YEARS WORK WITH BEEF CATTLE.

	November 6–February 26, 1909-1910—112 days.			October 12–January 31, 1910-1911—112 days.		
	Lot 1.	Lot 2.	Lot 3.	Lot 1.	Lot 2.	Lot 3.
	Cottonseed Meal, Corn Stover, Corn Silage.	Cottonseed Meal, Corn Silage.	Cottonseed Meal, Cottonseed Hulls.	Cottonseed Meal, Corn Stover, Corn Silage.	Cottonseed Meal, Corn Silage.	Cottonseed Meal, Cottonseed Hulls.
Initial value per hundred	4.00	4.00	4.00	4.50	4.50	4.50
Average initial weight	917.6	922.	946.7	915.6	915.2	899.5
Average final weight	1064.3	1072.9	1107.1	1061.5	1053.	1062.5
Total gain per steer	146.7	150.9	160.4	145.9	137.8	163.0
Average daily gain per steer	1.31	1.35	1.43	1.30	1.23	1.45
Average daily feed per steer	------	------	------	------	------	------
Cottonseed meal—Experimental period	8.14	8.14	8.14	6.77	6.77	6.77
Corn stover	16.52	------	------	20.80	------	------
Corn silage	23.17	35.36	------	23.64	32.55	------
Cottonseed hulls	------	------	17.92	------	------	21.60
Average amount of feed used per pound of gain	------	------	------	------	------	------
Cottonseed meal	6.21	6.04	5.69	5.20	5.50	4.65
Corn stover	12.61	------	------	15.93	------	------
Corn silage	17.69	26.24	------	18.14	26.45	------
Cottonseed hulls	------	------	12.52	------	------	14.90
Cost per hundred pounds gain	17.94	16.02	16.07	17.17	15.11	14.19
Valuation of steers per hundred	5.75	5.75	5.75	5.90	6.00	5.72½
Profit per steer	6.74	9.20	8.58	1.99	6.79	.31

Summary of Two Years Work.

The results of the two years experimental work in feeding steers are given in table 4. The total gains made by each lot were on the whole very satisfactory, yet it is hoped that by using a better grade of steers in the future, considerable improvement can be made in this respect. The average daily gains made by the steers fed cottonseed hulls as roughage were larger each year than the gains made by the other two lots. While it seems evident that cottonseed hulls will produce very satisfactory gains, the quality of the carcass was not as desirable, nor was the dressing percentage as high as that for the two lots receiving silage and stover.

The average daily gains made by lots 1 and 2 were practically the same. It will be noticed in table 4, comparing the results of the two years work, that it took less cottonseed meal to produce a pound of gain on cattle when fed with cottonseed hulls than when fed with corn silage or corn silage and corn stover combined. The cost per pound of gain is very high, which is accounted for first, by the class of steers fed, and second, by the high cost of the cottonseed meal and hulls. If these

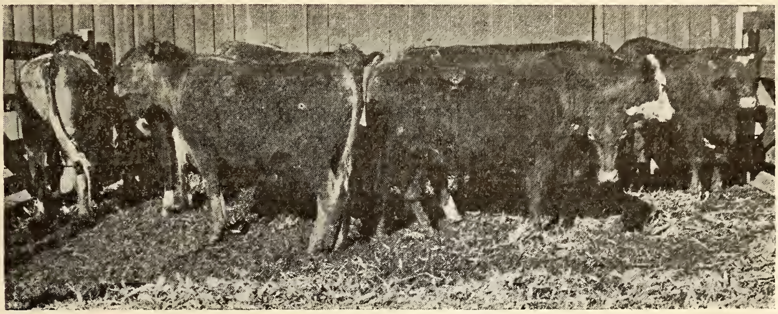

FIG. 5—Steers fed cottonseed meal, corn stover and corn silage in 1910-1911.

results are compared with the cost of gains on steers fattened in the corn belt it will be seen that the figures given in the table are very high. If the average daily gains are compared it will be found that the steers used in these experiments made approximately one-half the daily gains made by the class of cattle ordinarily used in the corn belt. It is evident, however, that if cottonseed meal remains at its present price, the cost of fattening steers will necessarily be high. This will necessitate a margin

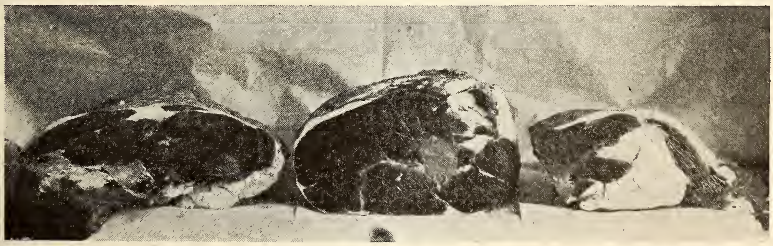

FIG. 6—Sirloin, round and porterhouse cuts from steers fed cottonseed meal, corn stover and corn silage in 1910-1911.

of at least $1.50 per hundred pounds live weight to assure feeders satisfactory results. It is possible, however, to reduce the cost of gains to a considerable extent by using a grade of steers which will take on larger daily gains.

During the first year the steers were all sold at the same price. Even under these conditions, however, it will be seen that the steers fed corn silage made a larger individual profit than any of the other lots, either the first or second year. While the steers were all sold at the same price the first year, the silage fed ones were finished better, having that firm touch characteristic of animals in good order. The lot fed cottonseed hulls was not as smooth, having more of the harsh rough handling quality which is often caused by a dry, unpalatable ration. While this ration was apparently relished, the large amount of crude fiber and its lack of succulence no doubt rendered it less digestible and consequently less efficient in producing a carcass of the best quality. A careful examination of the three lots shown in Figs. 2, 3 and 4 will show a marked difference in their condition. The hair and hide of lot 1 is dry, rough, and the steers appear to be unfinished. Lots 2 and 3 are smoother, the hair is in much better condition and the animals, as a whole, are in higher order. These observations were confirmed by the slaughter tests, made the second year. According to lots, the steers ranked in quality and finish as follows: first, lot 2, fed corn silage; second, lot 1, fed corn silage and corn stover; and third, lot 3, fed cottonseed hulls. While the distinction in price was not made the first year, the rank of the cattle in quality and finish was approximately the same as the rank given in the second year.

Average Daily Gain per Steer by Months.

The table showing the average daily gains of each lot by one month periods includes the preliminary period in the weights for the first month. The variation in gain is quite marked in this period, however, with one exception, the subsequent weights were fairly uniform. Lot 2 during the second year and the second month of the feeding period made a low average gain, and then dropped to slightly over one pound the third month. Taking the averages for each year, however, the results are very uniform. The lot fed corn silage as roughage has the lowest average daily gain for the two years and the lot fed cottonseed hulls as roughage has the highest average daily gain for the two years. The first year the average daily gain for lot 3 during the third and fourth month is given for the two months combined on account of a necessary omission in the weight of this lot the third month. Table 5 gives the average daily gains by months for the steers in each of the three lots fed during the two years.

TABLE 5—SHOWING AVERAGE DAILY GAINS PER STEER BY MONTHS FROM BEGINNING OF EXPERIMENT.

Period.	Average Daily Gains Per Steer.					
	In 1909-1910.			In 1910-1911.		
	Lot 1.	Lot 2.	Lot 3.	Lot 1.	Lot 2.	Lot 3.
First month	1.07	1.60	1.77	.73	.33	1.23
Second month	1.22	.98	1.49	1.24	2.10	1.90
Third month	1.86	1.51	1.57	1.45	1.05	1.20
Fourth month	.66	1.04		1.80	1.43	1.48
Average	1.31	1.34	1.43	1.30	1.23	1.45

Dressing Percentages.

The dressing percentages are given for the last year of the experiment only. Conditions would not permit obtaining this data the first year. The results secured during the second year, however, are quite striking. The average dressing percentage of the steers fed cottonseed hulls was 51.7 per cent; those fed corn silage dressed 53.8 per cent; and those fed corn silage and corn stover dressed 53.9 per cent.

The cattle fed corn silage were pronounced by three different parties to be the best, with a comparatively small difference between this lot and the cattle fed corn stover and corn silage.

The butcher reported the beef from the steers fed on corn silage to be the best, with a slight distinction between this lot and the lot fed corn stover and corn silage. The chief comments made by the butcher were that lots 1 and 2 cut to better advantage, giving a larger proportion of high grade cuts, both from the standpoint of quantity and quality. His patrons pronounced the meat to be of excellent grain and flavor.

In table 6 is given the dressing percentages of each steer used during the second year of the experiment, also the average dressing percentage for each of the three lots of cattle.

TABLE 6—SHOWING THE DRESSING PERCENTAGES OF STEERS FED IN THREE LOTS ON DIFFERENT RATIONS DURING 1910-1911.

Steer No.	Lot 1.			Lot 2.			Lot 3.		
	Cottonseed Meal, Corn Stover, Corn Silage.			Cottonseed Meal, Corn Silage.			Cottonseed Meal, Cottonseed Hulls.		
	Final Gross Weight.	Dressed Weight.	Dressing Percentage.	Final Gross Weight.	Dressed Weight.	Dressing Percentage.	Final Gross Weight.	Dressed Weight.	Dressing Percentage.
1	1135	568	50.0	1190	648	54.5	1179	622	52.8
2	1085	574	52.9	1004	540	53.8	1213	646	53.3
3	949	496	52.3	1059	584	55.1	1017	512	50.3
4	1159	652	56.3	914	500	54.7	949	496	52.3
5	1026	574	55.9	1259	626	49.7	1049	530	50.5
6	1014	572	56.4	989	562	56.8	1027	534	52.0
7	1045	556	53.2	1071	568	53.0	1039	520	50.0
8	1237	668	54.0	1024	540	52.7	1027	536	52.2
Total	8650	4660	53.9	8510	4568	53.8	8500	4396	51.7

Financial Statement.

Financial statements showing the absolute cost of fattening beef cattle will vary quite materially from year to year. For example the original cost of the cattle, their selling price, the cost of the feeds and the method of management will all be influencing factors. For this reason the following financial statements should not be taken to represent the actual cost of fattening beef cattle, but rather the relative cost depending on the kind and quality of feeds used as influenced by local conditions. The actual cost per pound of gain should be reduced by using a better grade of cattle, and by using better methods of management. However, the relative cost should not vary considerable from the figures given in the financial statements.

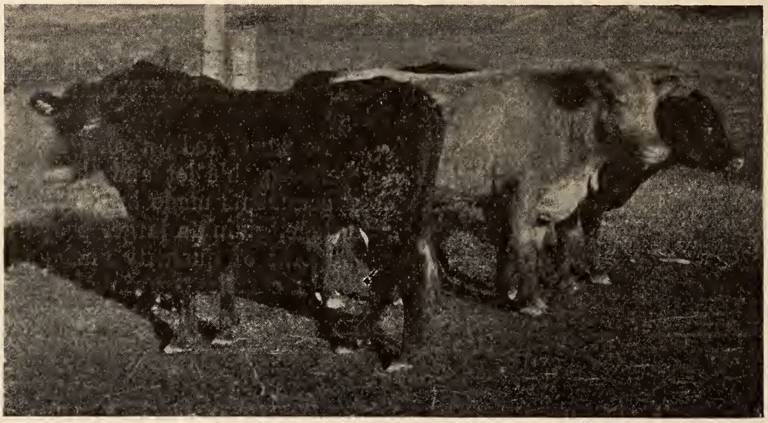

Fig. 7—Steers fed cottonseed meal and corn silage in 1910-1911.

It will be seen from these statements that the value of the manure produced has been credited to each lot of cattle. In considering the necessary selling price to break even on the transaction, however, the value of the manure was not credited. In studying these statements special attention should be given to the profit per steer, and the necessary selling price to break even on the transaction, as these are always the final factors for consideration.

Fig. 8—Porterhouse, round and sirloin cuts from steers fed cottonseed meal and corn silage in 1910-1911.

Lot 1. Seven steers fed cottonseed meal, corn stover and corn silage in 1909-1910.

To purchase of 7 steers, weight 6,423 lbs. @ $4.00 per hundred	$256.92
To feeding 6,380.5 lbs. cottonseed meal @ $30.00 per ton	95.70

To feeding 12,950 lbs. corn stover @ $8.00 per ton....	$ 51.80
To feeding 18,165 lbs. corn silage @ $2.75 per ton	24.98
To feeding 2,940 lbs. cottonseed hulls @ $8.00 per ton..	11.76
Total	$441.16
By sale of 7 steers, weight 7,450 lbs. @ $5.75 per hundred	428.37
To value of 30 tons manure @ $2.00 per ton	60.00
Total	$488.37
Profit on lot 1 (seven steers)	47.21
Profit per steer	6.74
Necessary selling price per hundred to break even on the transaction not counting the manure	5.92

ot 2. Seven steers fed cottonseed meal and corn silage in 1909-1910.

To purchase of 7 steers, weight 6,454 lbs. @ $4.00 per hundred	$258.16
To feeding 6,380.5 lbs cottonseed meal @ $30.00 per ton	95.70
To feeding 5,915 lbs. corn stover @ $8.00 per ton......	23.66
To feeding 27,720 lbs. corn silage @ $2.75 per ton....	38.12
To feeding 2,940 lbs. cottonseed hulls @ $8.00 per ton..	11.76
Total	$427.40
By sale of 7 steers, weight 7,510 lbs. @ $5.75 per hundred	431.82
To value of 30 tons manure @ $2.00 per ton..........	60.00
Total	$491.82
Profit on lot 2 (seven steers)	64.42
Profit per steer	9.20
Necessary selling price per hundred to break even on the transaction not counting the manure	5.69

Lot 3.—Seven steers fed cottonseed meal and cottonseed hulls in 1909-1910.

To purchase of 7 steers, weight 6,627 lbs. @ $4.00 per hundred	$265.08
To feeding 6,380.5 lbs. cottonseed meal @ $30.00 per ton	95.70
To feeding 6,020 lbs. corn stover @ $8.00 per ton......	24.08
To feeding 3,272.5 lbs. corn silage @ $2.75 per ton.....	4.50
To feeding 14,052.5 lbs. cottonseed hulls @ $8.00 per ton	56.21
Total	$445.57

By sale of 7 steers, weight 7,750 @ $5.75 per hundred	$445.62
To value of 30 tons manure @ $2.00 per ton	60.00
Total	$505.62
Profit on lot 3 (seven steers)	60.00
Profit per steer	8.58
Necessary selling price per hundred to break even on the transaction not counting the manure	5.75

Lot 1.—Eight steers fed cottonseed meal, corn stover and corn silage in 1910-1911.

To purchase of 8 steers weight, 7,325 lbs. @ $4.50 per hundred	$329.63
To feeding 6,065 lbs. cottonseed meal @ $30.00 per ton	90.99
To feeding 18,600 lbs. corn stover @ $8.00 per ton	74.40
To feeding 21,180 lbs. corn silage @ $2.75 per ton	29.12
To feeding 1,480 lbs. cottonseed hulls @ $8.00 per ton	5.92
Total	$530.05
By sale of 8 steers, weight 8,492 lbs. @ $5.90 per hundred	501.02
To value of 22.5 tons manure @ $2.00 per ton	45.00
Total	$546.02
Profit on lot 1 (eight steers)	15.97
Profit per steer	1.99
Necessary selling price per hundred to break even on the transaction not counting the manure	6.24

Lot 2. Eight steers fed cottonseed meal and corn silage in 1910-1911.

To purchase of 8 steers, weight 7,322 lbs. @ $4.50 per hundred	$329.49
To feeding 6,065.8 lbs. cottonseed meal @ $30.00 per ton	90.98
To feeding 29,160 lbs. corn silage @ $2.75 per ton	40.09
To feeding 7,400 lbs. corn stover @ $8.00 per ton	29.60
To feeding 1,400 lbs. cottonseed meal @ $8.00 per ton	5.92
Total	$496.08
By sale of 8 steers, weight 8,424 lbs. @ $6.00 per hundred	505.44
To value of 22.5 tons manure @ $2.00 per ton	45.00
Total	$550.44
Profit on lot 2 (eight steers)	54.35
Profit per steer	6.79
Necessary selling price per hundred to break even on the transaction not counting the manure	5.88

Lot 3. Eight steers fed cottonseed meal and cottonseed hulls in 1910-1911.

To purchase of 8 steers, weight 7,196 lbs. @ $4.50 per hundred	$323.82
To feeding 6,065.8 lbs. cottonseed meal @ $30.00 per ton	90.98
To feeding 19,352 lbs. cottonseed hulls @ $8.00 per ton	77.40
To feeding 3,600 lbs. corn stover @ $8.00 per ton	14.40
To feeding 1,640 lbs. corn silage @ $2.75 per ton	22.55
Total	$529.15
By sale of 8 steers, weight 8,500 lbs. @ $5.725 per hundred	486.62
To value of 22.5 tons manure @ $2.00 per ton	45.00
Total	$531.62
Profit on lot 3 (eight steers)	2.46
Profit per steer	.31
Necessary selling price per hundred to break even on the transaction not counting the manure	6.23

Discussion of Results.

On the whole, the results obtained from feeding steers experimentally have been satisfactory. There is necessity, however, for improvement by making a more rigid selection of feeders. Even with the Experiment Station cattle, the writer hopes to get the subject on a more practical basis making the profits larger than heretofore, and at the same time derive accurate results from an experimental standpoint.

FIG. 9—Steers fed cottonseed meal and cottonseed hulls in 1910-1911.

The financial statements given cover the exact cost of the steers through the experimental period. No account was taken of the feeds used or gains made during the preliminary period. The gains were not large during the latter period, however, as the steers used most of the feed in regaining their original weight.

FIG. 10.—Round, porterhouse and sirloin cuts from steers fed cottonseed meal and cottonseed hulls in 1910-1911.

The writer is not fully decided regarding the difference in cost of the gains on the steers fed corn silage, and those fed corn silage and corn stover. Both years the latter ration gave the most expensive gains. The dressing percentage was practically the same for lots 1 and 2, while the difference in the quality of the meat of each lot was not marked. The results show clearly that corn silage is a valuable roughage in the ration for beef cattle. The results obtained are not the same that have been secured under other conditions. It should be remembered, however, that the feeds available for beef production in the South are quite different from those used in other sections which necessitates special work by Southern stations to determine the value of the various feeds and combinations.

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NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

WEST RALEIGH

FEEDING AND MANAGEMENT OF BEEF CATTLE

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

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Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,

West Raleigh, N. C.

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SUMMARY

The feeding of beef cattle should occupy an important place in our system of agriculture because of the additional value thus obtained from cottonseed meal, the chief concentrated feed used in this State.

The soils of the State are generally in need of large quantities of humus, which can be supplied to a large extent from manure. The cheap roughages and concentrated feeds used for fattening beef cattle will when turned into manure supply the soil with this material.

More attention should be paid to the selection of feeding cattle. There is a tendency at present to buy a cheap grade of mixed cattle, which will use approximately the same amount of feed as good cattle, but which will neither gain as rapidly, nor increase the value of the finished carcass to the same extent.

After shipping cattle from the mountains, it is a good plan to feed them on roughages largely for two or three days. A small amount of corn silage will be beneficial in overcoming any trouble incident to the direct change from pasture to dry feeds. A small amount of cottonseed meal may be used with the silage and dry roughage during this period. Not more than one pound of the meal should be fed daily, however, during the first few days of the feeding period.

Beef cattle should not be cramped in muddy, filthy, unventilated quarters. They can withstand considerable cold without harmful effects, although they should not be subjected to undue exposure. An open shed protected on the north, east and west is sufficient for feeding beef cattle. In saving the manure, however, it is best to confine them in roomy sheds or barns partially open to the south.

If the sheds are large, roomy and well ventilated and water is supplied inside of the building it is not necessary to allow cattle the run of an open lot. In fact, such a practice is not advisable under Southern conditions.

Water and salt should be kept continually before the steers. By so doing they will never take more than is necessary, while if they are supplied at irregular intervals considerable trouble may arise. The idea that water and salt should be given in limited quantities is a mistake, as this practice will be detrimental to the best interests of the cattle feeder.

For a short feeding period ranging from one hundred to one hundred and twenty days not more than four to five weeks should be required to get steers on full feed. The amount of roughage fed should be determined by the appetite of the animals. No more should be given than will be cleaned up readily at each feed.

The cottonseed meal part of the ration should not be increased on the average more than two pounds per animal per week. By feeding one pound of meal per steer for the first few days and then increasing it at the above rate, the steers will be on a full ration of seven to eight pounds about the end of the fifth week.

In many cases cattle are fed too much cottonseed meal, especially during the preliminary period. The writer knows of certain instances in this State where cattle were started on a ration containing four pounds of cottonseed meal per head daily. This practice can not bring other than unsatisfactory results.

If the cottonseed meal is fed at the rate of three-quarters of a pound per hundred pounds live weight, no trouble should arise from its use. A thousand pound steer on full feed would get at this rate seven and one-half pounds per day, which is a safe and efficient ration for a one hundred to one hundred and twenty day feeding period.

If a thousand pound steer is fed from 900 to 1,000 pounds of cottonseed meal properly distributed over a feeding period of one hundred to one hundred and twenty days the results should be satisfactory.

After cattle once go on fattening feeds, they should be put in marketable condition as rapidly as possible. Such a practice will insure larger financial returns. Care should be taken, however, not to unduly increase the rations in the beginning as trouble is likely to arise if too much cottonseed meal is given.

A good grade of feeding cattle should gain at least two pounds per animal daily, if properly fed. By using a better grade of cattle, the gains will not only be increased, but the quality of the finished carcass will be better, and it will sell for a higher price per pound.

Considering the condition of the beef cattle industry of the State at present, the most satisfactory financial results will be obtained usually by selling the finished cattle at home. The average grade of cattle fed in the State at present will not net as large returns on the central markets as on the home markets. The farmer can afford to take from forty to fifty cents less per hundred pounds live weight, and sell his cattle at home, thus avoiding the heavy shrinkage incident to shipping and the uncertainties of the central markets.

FEEDING AND MANAGEMENT OF BEEF CATTLE

By R. S. Curtis.

Reasons for Feeding.

The reasons for feeding beef cattle in the South are evident to those who have given soil management serious consideration. While it is not absolutely necessary to feed cattle on the farm to maintain the fertility of the soil, it is recognized as an important factor toward this end. The by-products of cottonseed are at our door and the South at present is using for cattle feeding purposes only a small portion of the cottonseed meal which it manufactures. The exports of cottonseed and cottonseed meal are approximately 1,000,000 tons yearly, while large amounts of the meal used in the State are used directly for fertilizing purposes. This seems like a grave mistake when a good grade of feeding cattle can be obtained in the mountains of the State to turn this cottonseed meal into beef and manure. If the feeders of other States can afford to ship these cattle for feeding purposes, there seems to be no good reason why they should not be fed in this State on cottonseed meal which has nearly double the feeding value of corn. Many of these feeding cattle are handled by two or three parties, each realizing their profit, after which Virginia, Tennessee or South Carolina feeders fatten them and realize even then satisfactory returns on the transaction. If our farmer feeders buy these cattle direct from the growers, thus saving the middleman's profit, it will be a good investment to aid in restoring some of the impoverished farms.

It may be conservatively stated that all farmers who will feed a few beef cattle each winter, will soon double and even triple the value of their cultivated lands. Manure will bring about permanent improvement in the soil which commercial fertilizers as ordinarily used can not accomplish alone. The fertilizing value of cottonseed meal used for feeding purposes and returned in the manure will be at least seventy-five per cent of its original value. Therefore by feeding it to beef cattle its entire feeding value, and three-fourths of its fertilizing value can be obtained against its fertilizing value alone when used directly in the field.

A proposition of this kind which has been shown to be practical by actual demonstration should cause many farmers to give the matter serious consideration. Educaton along this line is imperative. It means richer farm lands and larger and more profitable crops for those who use conservative judgment in putting the practice into operation.

The Beef Cattle Industry in North Carolina.

The beef cattle industry at present is in an unsatisfactory condition for two reasons. First, many of the farmers who feed cattle live in the city, having regular employment therein, and are conducting their farms as an adjunct to their city business. This necessitates the employment of laborers usually very unskilled in the feeding and management of live stock. Even with feeds having no detrimental properties such as cottonseed meal has, the industry would suffer to a material extent under such management. Because of our dependence on cottonseed meal to furnish the concentrated portion of the ration, the condi-

FIG. 1.—A water supply system of 5,000 gallons capacity suitable for cattle feeding and general farm purposes.

tion is especially unfortunate for the feeder. The writer has visited a number of farms where cattle were being fed, and unfortunately in many instances unbusiness-like methods of feeding were in use. Cottonseed meal, to return the most satisfactory results, must be fed with care and judgment. As a result of slack methods, farmers are reporting small gains and in exceptional cases a depreciation in the value of the original animals. Such results can be overcome by using a specific plan in administering the rations. Unless some definite method of feeding is followed in all important details, unsatisfactory results are sure to follow. The writer will attempt to outline some of the most important factors to be taken into consideration in order to secure good average results. If the large feeders of the corn belt used such a system of management as prevails in general throughout this State they would not be able to follow the cattle feeding business many years. In a number of instances the writer has seen cattle in this State with a constant supply of cottonseed meal and cottonseed hulls before them, the feed troughs never being entirely cleaned of their contents.

This accumulation of feed in the trough is sure to bring on troubles incident to the use of large quantities of cottonseed meal. This system of feeding even with the ordinary feeds would soon bring about disastrous results. By using care and judgment in feeding, this State can be made second to none in the production of beef cattle.

Season for Feeding.

For several reasons the winter season is naturally the best time to feed beef cattle in this section of the country.

First, it is difficult to buy feeding cattle in the spring. In the mountain country, where practically all the feeding cattle are produced, the grazers will not sell in the spring of the year except for exorbitant prices, because of their desire to take advantage of the cheap gains which can be made during the spring, summer and early fall. The feeder can not pay the necessary price to secure feeders in the spring and come out even on the transaction. After these cattle have made their maximum gains on pasture, which will be from the first to the fifteenth of October, the grazers are ready to sell. Naturally these cattle can be bought at this season at a lower price than at any other time of the year.

Second, cottonseed meal can be purchased cheaper during the fall months, when the season's crop is first placed on the market.

Third, the farmer has more time during the winter season to supervise the feeding of cattle and distribute the manure over the farm.

Fourth, a higher price can be obtained for finished cattle during the winter and early spring months because the competition of grain fed cattle during the spring and summer with grass fattened cattle would force the price of the grain fed cattle to an unprofitable figure. Furthermore, the climatic conditions in this State makes the winter season very desirable for feeding beef cattle. The cold is not severe enough to influence the gains, in fact, considering all the factors involved, the winter season is more favorable for cattle feeding than the summer season.

Method of Feeding.

The usual method followed in feeding beef cattle is to divide the daily ration into two equal feeds which are given in the morning about seven and in the evening about four. This is a matter which should receive close attention as no one thing pays better in the feed lot than regularity in feeding and caring for the steers.

The length of the feeding period under Southern conditions should range from one hundred to one hundred and twenty days, the period being necessarily limited in length because of the effect of cottonseed meal after a certain rather definite time. The writer believes that the shorter feeding period with the maximum safe ration of meal is better than the prolonged period with the smaller ration, a plan followed by some feeders.

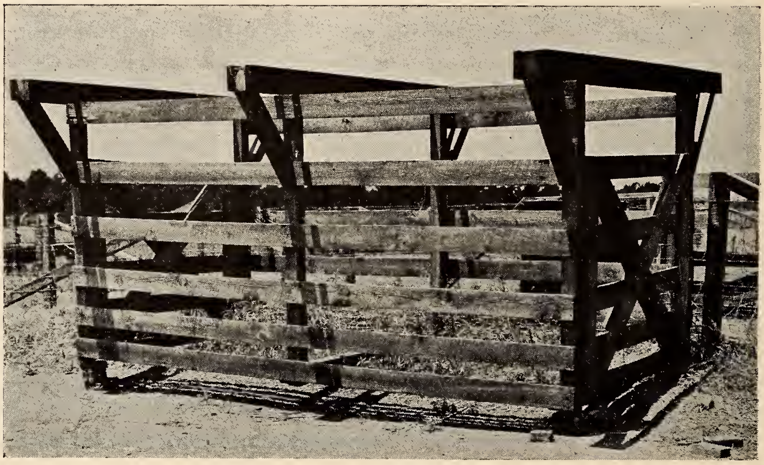

FIG. 2.—A movable scale rack for weighing beef cattle. When supplied with rollers and a track, it can be removed from the scales for weighing roughage.

The latter practice rarely pays except for young stock which it is intended to force later. Beef cattle intended for the market when finished ,should be forced to maturity as rapidly as conditions will permit. In all cases mature judgment should be used in keeping the steers from going off feed. It is far better to hold them in check somewhat than to allow this condition to arise.

If the concentrated part of the ration consists of cottonseed meal entirely steers will rarely make satisfactory gains or increase much in value after one hundred and twenty days. It may be possible to feed somewhat beyond this period but unless there is a corresponding gain and increase in the value of the cattle such a practice will rarely pay for the extra feed given.

Feeding Equipment.

The most economical method of feeding beef cattle in this State is to confine them either in small lots where shelter is easily accessible, or under large roomy well ventilated barns or sheds. By following this latter plan the manure will all be conserved, which is an important factor. The former method, while less expensive, has the disadvantage of eaving part of the manure exposed to the weather. However, if the eed lot is small and kept well bedded, the loss of manure may not be reat. The writer prefers a large covered barn, well ventilated, with vater and salt provided inside. A barn of this type need not be ex- ensive. The principal cost will be in the roof, the sheltered sides being oarded up only part way. For those who care to allow their cattle in he open a short time each day or at frequent intervals, a small lot to he south may be provided. However, if the barn is large, amply venti- ated and the cattle are not cramped, there is no necessity for allowing hem outside. Beef cattle should be kept quiet, to make the most rapid ains.

The practice of allowing the cattle access to a large open lot is not onducive to rapid and economical gains. Stall feeding sometimes prac- iced in the State, is also expensive because of the extra cost of buildings nd labor involved. The former method described is advocated by the argest and most successful feeders. The cattle are easily fed and they ave practically the same advantages as the stall-fed animal. From he financial standpoint, stall feeding is not practical under Southern onditions, and it is doubtful whether it is a judicious practice in other ections.

Grades of Feeders.

In Figs. 3, 4 and 5 is shown the difference in the grades of feeding attle found on the various markets in this State.

The common grade of feeders are light and rough and are lacking in lesh, capacity and early maturing qualities. Their weight ranges from 00 to 950 pounds. Such steers make small gains and do not improve n value materially even with careful feeding. The same statement ap-

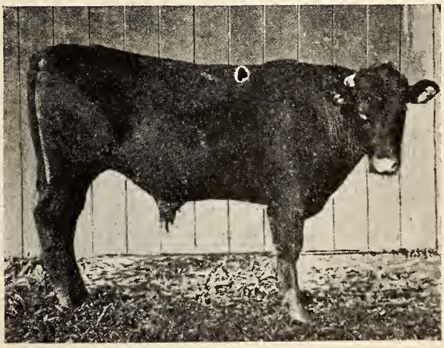

FIG. 3.—A very faulty feeder, lacking in weight, capacity and breeding.

plies to the mixed lots consisting of inferior steers, cows, heifers and oxen which are frequently used. These feeders are generally of mixed blood, not uniform in size or weight, making small gains with an uneven finish. Neither of the two classes are satisfactory for the discriminat- ing market.

Feeders which class as medium consist of steers weighing from 900 to 1,000 pounds. They are fairly uniform in size, although the type varies to a limited extent. The breeding is more uniform than that of the common grades. They possess more natural flesh or muscle than common feeders and they are smoother and more uniform in maturing. This class of cattle for the average feeder, especially the beginner, will give very satisfactory results as they can generally be purchased at a reasonable price and sold at a figure sufficient to clear the feeder without the necessity of straining market quotations.

The good to choice grade of feeding cattle consists of steers weighing from 950 to 1,100 pounds. They are of uniform breeding, average well in size, type and color, possess considerable quality, are smooth and well muscled and finish evenly. This grade of cattle goes mostly to Virginia feeders who bid the highest prices for them. These cattle are generally finished on corn and sold at the central shipping points for prices considerably higher than the quotations on local markets.

The above classification has not been given with the idea that it is exhaustive or complete but for the cattle feeders of this State it will serve as a rough guide in selecting cattle for fattening purposes.

Selection and Cost of Feeders.

The selection and purchase of feeding cattle should receive very careful attention. This is one of the most important factors in making a success of the feeding business. No matter how well a steer may be

Fig. 4.—A steer with sufficient weight, but one with a low dressing percentage. The back is low, the ribs are too flat, the rear quarters are light, and the paunch contains too much offal.

fed and cared for, if the margin between the buying and selling price is not properly adjusted, loss is certain. Too much emphasis can not be placed on this point. The grade of feeders purchased will necessarily determine the price within certain limits. The class of cattle to be fed hould first be decided upon and then the price adjusted according to narket conditions. In this State the major portion of the feeders hipped to the Eastern and Piedmont sections are common cattle. They nay be divided into two general classes, namely, plain rough steers and nixed feeders consisting of cows, heifers, stags and oxen. While there nay be a market for a limited number of these, they are unsatisfactory n the feed lot as they make small gains, and do not sell satisfactorily ecause of their lack of breeding, condition and uniformity.

Good feeders consist of steers, low-set, broad and deep, with good ength of body smoothly and heavily covered with natural flesh or nuscle. An animal of this type will gain well in the feed lot under ormal conditions. It is possible to make gains on such steers ranging rom two to three pounds per day. The ordinary class of feeders used hroughout the State, under average conditions, will gain from one to ne and one-half pounds daily. If sufficient care and time is taken in urchasing feeding cattle, much improvement can be effected in this respect. At present a good average grade of feeders can be purchased or four cents per pound or thereabouts, mountain weights, and the increased gains which can be made on this class of cattle with the better selling price will more than overbalance the difference in cost of these cattle and plain rough feeders.

Feeding cattle should be neither too old nor too young. Very young steers will not fatten readily, and especially is this true considering the nitrogenous character of cottonseed meal. There is not so much danger, however, in getting stock too young as there is in buying those which are old, unthrifty and very late in maturing qualities. The best results will be gotten from two and three year old steers under Southern conditions. They will fatten readily, and will not be so likely to become affected by heavy cottonseed meal rations as younger steers.

Frequency and Regularity of Feeding.

Steers intended for the open market are ordinarily fed twice daily. During the winter season when most of the cattle are fed, the feeding should be done at some regular time each day. Seven in the morning is not too early, as the steers will generally be ready for their feed at this time. In the afternoon, if they are fed about four-thirty, they will have time to consume their feed before night. It is not so important that they be fed exactly at these hours, however, it is important that regularity in the hours of feeding be followed throughout the feeding period. If the hours given above interfere with farm work, they may be changed to fit in with this work, although it would not be best to depart radically from the hours stated. The time between feeds should be divided as equally as possible, and these hours followed with considerable regularity.

Water and Salt.

Water and salt should be supplied regularly. The best plan to follow is to keep the water and salt where the steers can have free access to them. In this way they will satisfy their appetite daily and not take an undue quantity at any time. There is a mistaken idea prevalent in some sections of the State, that water and salt should be supplied at certain intervals during the day or week. A practice of this kind is sure to result in trouble in a large number of cases. If the steers are given free access to these necessities they will rarely if ever take more than needed.

Available Feeds.

The feeds which are available in the State, from an economical standpoint, are cottonseed meal, corn stover, corn silage, and cottonseed hulls. In certain instances, varying with local conditions, other roughages may be used but their importance in cattle feeding is limited. For example, cowpea hay is a standard feed, but the price is prohibitive for fattening beef cattle. In feeding dairy cattle this feed may be used because of the larger and more profitable returns.

Cottonseed meal without doubt will form the main concentrated feed for fattening cattle. It is the only concentrate produced in sufficient quantities at a price which will justify the cattle feeder in using it.

Corn stover and corn silage may be produced on the farm in quantities sufficient to fatten many more cattle than are now annually fed. They are both well adapted to feed with cottonseed meal because of their carbonaceous nature. Better use should be made of these feeds, considering the price at which they can be produced as compared with the market price of cottonseed hulls. While the latter gives very satisfactory results, the fact should not be lost sight of that the farmers of this State allow large quantities of corn stover to waste which can be used to equal or better advantage than the hulls for feeding beef cattle.

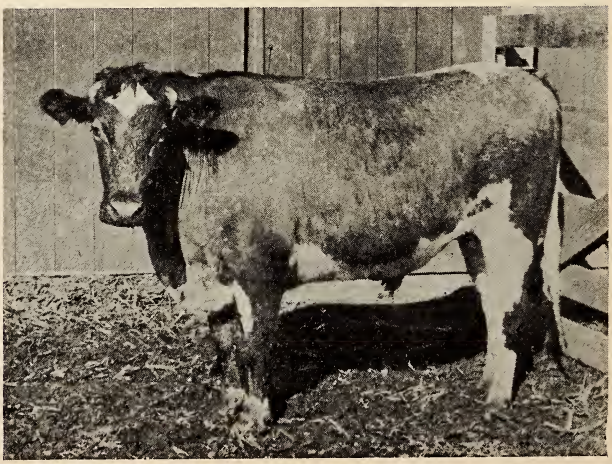

FIG. 5.—This steer will grade as a fair feeder, although more weight in the rear quarters would be desirable. A steer of this type will fatten readily and finish smoothly.

Likewise corn silage which has produced such satisfactory results in the experimental work at this Station should be more widely used. In the Northern and Western States this feed is rapidly finding a place in the beef cattle ration. Its desirable effect has always been very evident wherever it has been fed. If more of the corn crop was preserved in this way it would mean larger profits in the cattle feeding industry.

With cottonseed meal valued at $28.00 to $30.00 per ton, corn stover at $7.00 to $8.00 and corn silage at $2.50 to $3.00, there is little excuse for using such large quantities of cottonseed hulls which will cost from $7.00 to $11.00 per ton, the market price depending on the season of the year.

Corn Silage for Beef Production.

The indications from the experimental data at hand are that corn silage will become an important factor in beef production in the State. In Station Bulletin 218 are given some results obtained with this feed. The average profit per steer obtained from two years work was in favor of the cattle fed on cottonseed meal, and corn silage alone for roughage. Whether the same results will always be obtained is to be determined. It is thought, however, that larger quantities of cottonseed meal can be fed successfully by using corn silage in the ration. This is a point of special significance to be reported in a subsequent bulletin.

As a general thing, cattle which are fed silage make better use of their feed and finish more satisfactorily. The hide and hair is kept mellow and glossy, which is a good indication of thrift in fattening cattle. In Indiana about seven per cent of the cattle feeders are using corn silage in their beef cattle rations. In a recent bulletin of that Station it is stated that the addition of corn silage to a ration of shelled corn, cottonseed meal and clover hay, resulted in more rapid and cheaper gains, and greater profits per steer than any other ration fed. It is stated that the results indicate that corn silage may be used profitably as a portion of the ration in finishing steers. Workers at other stations have shown the advantages of corn silage in beef production, although the kind of supplementary feeds used with silage will vary the results obtained. Because of this fact, the use of corn silage with cottonseed meal in the South is a problem in itself, which the writer hopes to work out in a definite form.

Preliminary Feeding Period.

One of the greatest sources of trouble among cattle feeders of the State is the irregular methods used in getting cattle on full feed. With the safest of feeds, some men by careless methods and undue crowding of the cattle may get them off feed, which brings on scouring, a very troublesome condition in the feed lot. With cottonseed meal, a rich nitrogenous feed of a laxative nature, and toxic when fed in excessive quantities, extra precaution should be taken in getting steers up to full feed, and keeping them in a normal condition thereafter. A number of cases have been reported where the results from the meal feeding have not been satisfactory. The trouble was no doubt caused largely by irregular feeding on varying quantities of the meal or by forcing the cattle too fast in the beginning. Such a practice in the feed lot can never bring other than unsatisfactory results.

The data given in Table 1 will be of considerable aid to cattle feeders if they will follow the general plan outlined of increasing the cottonseed meal part of the ration as given therein. These rations are figured out on a basis of one steer, ten steers and multiples of ten up to one hundred. By selecting the horizontal column giving the number of steers being fed, the proper bi-weekly increase of meal may be determined by the figures following to the right of the page. For example, if thirty steers are being fed, they should receive 15 pounds of cottonseed meal each feed the first half of the week, 22.5 pounds each feed the last half of the week, 30 pounds each feed the beginning of the second week, and so on through the period until they are on a full ration of 210 pounds the fifth week, which makes the total ration for each steer seven and one-half pounds daily.

It will very likely not be best to increase the meal to the amount indicated in the last half of the sixth week for the final period unless the steers are of an unusual weight. With present knowledge of the subject, it is suggested that seven to seven and one-half pounds should constitute the maximum daily ration of meal during the final period.

TABLE 1.—GIVING THE QUANT I OF COTTONSEED MEAL IN POUNDS TO FEED DURING SUCCESSIVE STAGES OF THE PRELIMINARY PERIOD.

Number of Steers	Time of Feeding	Number of Week: First Week		Second Week		Third Week		Fourth Week		Fifth Week		Sixth Week	
1 steer	a. m. p. m.	.5 .5	.75 .75	1. 1.	1.25 1.25	1.5 1.5	1.75 1.75	2. 2.	2.5 2.5	3. 3.	3.5 3.5	3.5 3.5	4 4
10 steers	a. m. p. m.	5.0 5.0	7.50 7.50	10. 10.	12.50 12.50	15.0 15.0	17.50 17.50	20. 20.	25.0 25.0	30. 30.	35.0 35.0	35.0 35.0	40 40
20 steers	a. m. p. m.	10.0 10.0	15.00 15.00	20. 20.	25.00 25.00	30.0 30.0	35.00 35.00	40. 40.	50.0 50.0	60. 60,	70.0 70.0	70.0 70.0	80 80
30 steers	a. m. p. m.	15.0 15.0	22.50 22.50	30. 30.	37.50 37.50	45.0 45.0	52.50 52.50	60. 60.	75.0 75.0	90. 90.	105.0 105.0	105.0 105.0	120 120
40 steers	a. m. p. m.	20.0 20.0	30.00 30.00	40. 40.	50.0 50.0	60.0 60.0	70.00 70.00	80. 80.	100.0 100.0	120. 120.	140.0 140.0	140.0 140.0	160 160
50 steers	a. m. p. m.	25.0 25.0	37.50 37.50	50. 50.	62.5 62.5	75.0 75.0	87.50 87.50	100. 100.	125.0 125.0	150. 150.	175.0 175.0	175.0 175.0	200 200
60 steers	a. m. p. m.	30.0 30.0	45.00 45.00	60. 60.	75.0 75.0	90.0 90.0	105.00 105.00	120. 120.	150.0 150.0	180. 180.	210.0 210.0	210.0 210.0	240 240
70 steers	a. m. p. m.	35.0 35.0	52.50 52.50	70. 70.	87.5 87.5	105.0 105.0	122.50 122.50	140. 140.	175.0 175.0	210. 210.	245.0 245.0	245.0 245.0	280 280
80 steers	a. m. p. m.	40.0 40.0	60.00 60.00	80. 80.	100.0 100.0	120.0 120.0	140.00 140.00	160. 160.	200.0 200.0	240. 240.	280.0 280.0	280.0 280.0	320 320
90 steers	a. m. p. m.	45.0 45.0	67.50 67.50	90. 90.	112.5 112.5	135.0 135.0	157.50 157.50	180. 180.	225.0 225.0	270. 270.	315.0 315.0	315.0 315.0	360 360
100 steers	a. m. p. m.	50.0 50.0	75.00 75.00	100. 100.	125.0 125.0	150.0 150.0	175.00 175.00	200. 200.	250.0 250.0	300. 300.	350.0 350.0	350.0 350.0	400 400

Final Feeding Period.

The final feeding period is the time during which steers should make ·apid progress toward fitting for market. When they are first placed ɔn feed it is necessary to proceed slowly until the animals adapt themselves to the change. During this time the gains will be small as the :hief object during the preliminary period should be to regain the shrinkage lost in shipping and to adapt the digestive system to the new feeds.

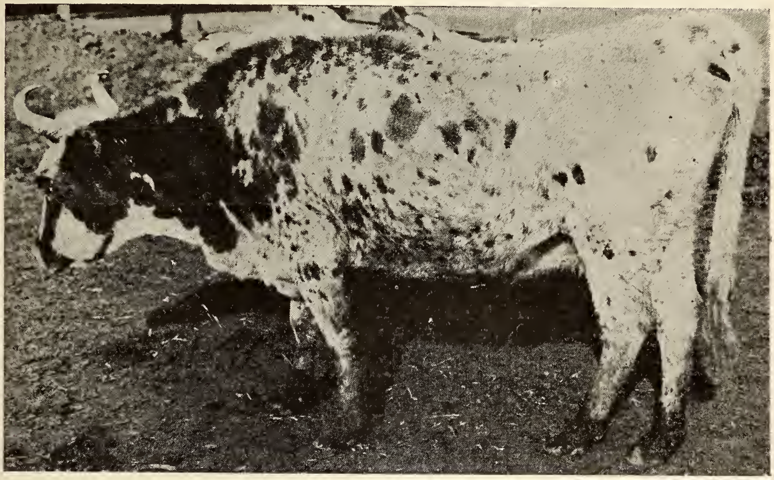

Fig. 6.—A type of animal too often seen in the feed lots of this State. Cattle of such breeding are too inferior to use high priced cottonseed meal.

After steers are once placed on a full ration, the fewer the changes in ind of feed, and other of their surroundings, the more satisfactory the esults will be, other things being equal. The only change which should e made will be the amount of feed, which should be regulated by the ppetite and condition of the animals. Changes should be made very radually, as there is nothing more fatal in steer feeding than irregular are and management. This is especially true when using a feed like ottonseed meal. A succulent feed like corn silage should be introduced nto the ration gradually and eliminated in the same way if for any eason this becomes necessary. Sudden changes to and from watery eeds, such as silage, often cause digestive disturbances such as scours, hich are very disastrous in the feed lot. It is important to use dry eeds with caution, yet there is not the same danger as with silage, which ontains about eighty per cent of water, a factor often responsible for he washy condition in steers fed corn silage alone. When steers are rst taken from the pasture it is a good plan to feed a small amount of orn silage with the dry roughage feeds. If this can be done it will elp materially in overcoming the effect of sudden changes from pasture ɔ dry feeds, now largely used for fattening steers.

The final feeding period should be characterized by regularity both on the part of the feeder and the animals. The appetite of the steers should be kept keen by regular and judicious feeding and the gains therefore made larger and more uniform. Any sudden departure from

FIG. 7.—The class of meat which comes from animals like that shown in Fig. 6. The cuts of meat are small, they lack marbling and are consequently tough and unpalatable.

this record should be taken as an indication of trouble either in the feeding or management. The sooner this condition is checked the better, as the unsatisfactory results often obtained are caused by lack of attention to these details.

Gains Per Day.

As a general thing the class of cattle used in this State for feeding purposes do not make profitable gains. Larger daily gains should be secured, which will reduce the cost of production. A large number of the cattle will not average over one and one-fourth pounds gain per day. A good grade of cattle should make at least two pounds gain daily, and even two and one-half pounds would not be unreasonable to expect of them. The better classes of cattle sold on the larger markets will make as high as three or three and one-half pounds gain daily when on full feed. In selecting cattle for feeding purposes, growthy steers with ample capacity for using feed should be secured. The angular type of animal so often seen in the feed lot is an inferior gainer, and a slow seller. The broad backed, low-set, deep bodied steer will, as a general thing, make much larger gains on an equal amount of feed, than the small angular type of animal.

Season of Marketing.

The season of marketing beef cattle in this State has a narrow range for the reason that practically all of the cattle fed come from the mountains of this State where the pastures generally begin to deteriorate about the first of October, so that the grazers contract to deliver the feeders from October 1st to 15th. For this reason most of the good cattle are put on feed by October 15th to November 1st.

It will be seen therefore that unless cattle are fed on roughage feeds temporarily in the fall a large portion of them will be placed on the market about the same time the following spring. A great many of the cattle are ready for market about March 1st of the following year. Such a condition necessarily causes an oversupply of fat cattle, especially on the local markets, where most of them fattened in this State are sold. If the beginning of the feeding period could be deferred for one month even, so that some of these cattle could be marketed between the time the major portion of the grain fed cattle are sold, and the grass cattle come on the market, they could be disposed of more readily and at better prices. As this is important, any system which can be devised to remedy it will be a great benefit to the cattle feeders of the State.

Selecting and Sorting for Market.

In buying cattle for feeding purposes, it is important that they be purchased at a reasonable price. Cattle well bought are half sold. Likewise, it is important to obtain the highest market price possible, and to do this the cattle should not only be fat but they should be uniform in size, type and quality.

FIG. 8.—A lot of 800-pound feeders, too young to fatten satisfactorily in a short feeding period, although otherwise they average very well in feeding qualities.

Some cattle feeders have the idea that the good cattle in the lot will sell the inferior ones. This is a mistake, and especially so when they are sold on a central market. On the other hand it is true that the inferior cattle will depress the selling price of the whole lot. Local butchers are not so critical, yet it is far better to have a uniform lot of cattle even for this market. In the large stock markets, the speculator makes a profitable business of buying mixed lots of stock, sorting them according to weight, quality and condition, and then reselling them at an advanced price because of their uniformity.

It is important that cattle feeders pay more attention to this point. An unsatisfactory sale is often the result of not giving these matters proper thought and care. When cattle are shipped or if a buyer comes to the farm they should be properly divided in the way mentioned above. If one-half of a lot of steers are in high condition, and one-half in low condition, it would be unwise to mix them with the idea that the steers in low condition would sell as well as the others. In a case of this kind, it would be much better to offer the good ones for sale in a lot by themselves and retain the others until they were fat.

Marketable Condition.

The quality of the meat obtained from a steer depends to a large extent upon the amount of fat the animal carries. However, it should not be understood that a steer must have an overabundance of fat in order to make prime beef, but they should be in sufficiently high condition to give succulence and flavor to the meat. A prime grade of meat should have among other important characterictics, a medium pad of outside fat, and should be well marbled with fat between the muscular tissues. Very few of the steers fattened in the State ever reach this condition. In fact, the majority of them are sold just when the veteran corn-belt cattle feeder would put them in the feed lot to fatten. This is a condition which must be overcome before the highest price can be obtained for fat cattle. Before the markets will discriminate between the different grades, classes and condition of cattle, they must have the different grades and classes provided for discrimination. A well fattened animal will dress out a larger percentage and a better quality of edible meat than one in medium condition, and for this reason the markets will pay more for the high grade well fattened animals. The situation may be such that it will not pay to put cattle in exceptionally high condition. However, in the South, where the feeding period is of short duration, it is necessary to push them to the limit of the feeding period in order to get them in the best possible market condition. For this reason it is not likely that cattle fed on cottonseed meal will become too fat.

Fig. 9.—A brisket from a high grade steer on the left, and a loin from a low grade cow on the right.

The principal indications of a well fattened animal are a fullness at the tongue root, at the base of the tail, a low well filled flank, a full twist and cod, all of which are correlated with the smooth, even and firm covering of body fat, which gives the rotundity of form characteristic of the fat animal.

Preparation for Shipment.

The preparation of cattle for shipment is very important. No matter how well steers may look at home if they are not properly prepared for shipment their shrinkage will be heavy and their condition will not be conducive to a ready and satisfactory sale at the stock yards.

From twelve to twenty-four hours before the cattle are loaded in the car, the grain ration should be cut down very materially, and dry roughage given instead. This is especially true if corn silage is fed, which is likely to cause a washy condition when the steers get heated and excited. As cottonseed meal is a laxative feed, great care should be used in feeding it for a day or two before shipment. It is a well known fact that grass fattened cattle shrink abnormally when shipped. In shipping cattle every precaution should be taken to withhold green feeds, such as grass, silage, or any of the concentrates, such as cottonseed meal and linseed meal, which are likely to purge the animals. It is a good plan to feed hay principally, the day before shipment. Timothy hay is recognized as being ideal for this purpose. If this can not be obtained, corn stover or cottonseed hulls will serve the purpose. Clover, alfalfa or cowpea hay should not be fed at this time because of their laxative character. Water and salt should be withheld for six to eight hours before shipment. The use of salt to secure a good fill of water is neither a paying proposition nor a legitimate practice.

The car should be well bedded with straw, sawdust or some other litter convenient for use, and the cattle should be loaded snugly, but not packed. Prior to shipment all undue excitement should be avoided. If these suggestions are followed the cattle should reach market in good condition, ready to eat and drink normally before sold. Careful and intelligent management will assure both the shipper and the buyer honest weights and satisfactory returns.

Cost of Shipping.

Usually the cattle feeder can afford to take from forty to fifty cents per hundred pounds less for his cattle on the local market. This is especially true for the beginner who may not be able to judge when cattle are ready for the market or when it is most advisable to ship for other reasons. The following figures will enable the feeder to determine with considerable accuracy what the shipping expenses will be to Baltimore on one carload of fat cattle, assuming the selling price to be six cents per hundred. The cost of shipping to Richmond would be somewhat less than the figures given below.

Shrinkage on 30 cattle, 40 pounds per head—1,200 lbs. @ 6 cents per pound	$ 72.00
Freight	66.00
Commission charges	30.00
Yardage, feeding and weighing	12.00
Total	$180.00

These figures are subject to modification according to the location of the feeder; however, the principal difference would be on the shrinkage and freight charges. It will take considerable experience to judge just when it will pay to ship and when to sell at home. If the price offered at the farm is within reason, however, it will usually not pay to take a material risk. Any one who contemplates shipping should be governed largely by the price offered for the cattle at home and the quotations on the central market. It should be remembered that steers from the quarantine area are usually quoted at twenty-five to thirty-five cents less per hundred pounds than steers from the non-quarantine areas, although the discrimination in price is not as great as heretofore.

Market Classification.

The subject of market classification is a special study in itself, especially on the larger central markets. It is necessary, however, for the cattle feeder to have a general knowledge of the grades and classes of cattle on the market where his cattle are usually sold. For example, it must be known where cattle will grade in order to study market quotations intelligently and determine the approximate price for which a given lot of cattle will sell. The farmer who has a load of butcher cattle for sale would be at a loss to know what his cattle would likely sell for, unless he actually knew that they would grade as butcher stock. These facts must be known by the man who expects to sell on the central markets intelligently.

Fig. 10.—A lot of 950-pound steers which will grade as medium feeders. This class of cattle is very satisfactory for the average feeder, especially the beginner.

The following classification is used by a Baltimore commission firm and will give some idea of the range in grades and classes of cattle on that market. The figures given are March quotations. It will be noticed that no quotations are given on export cattle during this season of the year, as the supply is limited.

MARKET CLASSES AND QUOTATIONS.

Choice Export Steers	.....	to	.....
Medium Export Steers	.....	to	.....
Choice Butcher Steers	$6.50	to	$7.00
Medium Butcher Steers	5.50	to	6.50
Good Fat Heifers	5.00	to	6.25
Light Heifers	3.00	to	5.00
Fat Cows	2.00	to	5.50
Bulls	4.00	to	6.00
Oxen	3.00	to	6.50
Fresh Cows	15.00	to	60.00
Good Fat Calves	9.00	to	9.50
Light Common Calves	6.00	to	8.00

Most of the steers sold from this State will grade as butcher stock and large portion of them will go in as medium butcher steers. Virginia, Vest Virginia, Kentucky, Pennsylvania, Ohio and Maryland furnish ome cattle for the export market, but they are corn fed, having plenty f weight, quality and condition. The product from North Carolina s most likely to be a butcher cattle trade in the steer classes.

Margin of Profit.

The margin of profit on cattle, considering their original cost, the cost f the feed, and the market for fat cattle should be from $1.50 to $1.75 er hundred pounds. Even with this margin it is not possible to obtain n appreciable profit from cattle feeding. It is possible, however, to lear the manure, pay for the labor and get possibly from one to two ollars profit per steer. If this profit can be obtained, the cattle feeder hould consider himself very fortunate, as many of them lose, although n a great many cases considerable loss could be avoided by a better sysem of management. If the manure can be cleared, it is well worth the ime spent in caring for the cattle because of the value of this product n improving the farms. A large part of the fertility in cottonseed meal s left in the manure, which amply justifies the farmer in feeding beef attle. If the steers can be fattened and the fertility of the meal reained on the farm without an actual outlay of money it is an economical ractice in building up the farms of this State.

Fig. 11.—The class of meat which comes from steers of the grade shown in Fig. 10. Contrast with the cuts of meat shown in Fig. 7.

The principal obstacle to overcome is to get the industry on a firmer inancial basis. By reducing the cost of production which is now rather igh, the necessary margin to break even can be reduced, thus making ossible a larger percentage of profit in the business. When this can be one more cattle will be fed.

Scours.

The man who can not keep scours out of his feed lot is not in a posiion to make a success of the cattle feeding business. This trouble is the ane of the cattle feeder wherever it becomes prevalent. It is an inication that the digestive system is out of condition, which is caused argely by careless feeding and management. The droppings from a teer which is doing well should be dark in color and firm in consistency.

Any washy or loose condition should be remedied at once, as a steer affected in this way will not only stop gaining, but actually lose flesh if the trouble continues for any length of time.

Under the system of feeding followed in this State, scours are more likely to give trouble because of the laxative nature of cottonseed meal. If corn silage is fed either alone or with some dry roughage it may have a tendency to bring about a lax condition, although this is not likely to happen under careful management. One of the principal precautions to take is to start the steers on a light ration of meal and increase it gradually. If this is done and average judgment is used thereafter in feeding no trouble should occur.

Thrush or Foul-of-the-Foot.

Thrush or foul of the foot is caused by allowing steers to stand in the sheds or yards in manure which has been accumulating for considerable time. For this reason the manure should not be allowed to remain in the barns and yards for an undue length of time. Plenty of bedding should be provided to overcome this trouble as well as to aid in conserving the manure. There is very little that can be done for fattening steers affected with this trouble except to remove the cause. Care should be taken to provide clean and dry bedding. If the steers are not allowed to wade in filthy lots this trouble is not likely to develop.

Effects of Overfeeding with Cottonseed Meal.

It is probably generally known that when cottonseed meal is fed in large quantities, during prolonged periods, it causes either blindness, staggering or possibly death in extreme cases. The writer is not aware of any deaths in this State, although it is stated that a few have occurred. As a general thing with beef cattle, the first indication of the trouble is seen in the failure to make uniform gains. This is followed by a dry rough coat of hair, dullness, sleepiness, possibly a staggering gait and loss of appetite in prolonged cases. Because of this trouble arising after feeding cottonseed meal heavily for one hundred to one hundred and twenty days the chances for making prime fat cattle are greatly reduced unless they are finished on some other concentrate. After steers from two to three years old have been fed from 900 to 1,000 pounds of cottonseed meal, a keen watch should be kept of their general condition and the progress they are making. When the gains begin to grow small it is a good indication that the cattle have taken as much cottonseed meal as the system will stand. When this condition arises they should be marketed as soon as possible, providing this has not already been done before the effects of the cottonseed meal were noticed.

ULLETIN 220 AUGUST, 1911

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

CARE AND MANAGEMENT OF THE DAIRY HERD

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

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Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,

WEST RALEIGH, N. C.

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CARE AND MANAGEMENT OF THE DAIRY HERD.

By J. C. McNutt.

The increasing demand for high class dairy products in North Carolina is a clear indication that more farmers in the State might profitably devote time and money to developing good dairy herds. Up to the present time the number of dairy cows has been so small and the average production so low that it has been necessary to bring large quantities of dairy products into the State every year. There is absolutely no reason why sufficient milk and butter could not be produced within the State to supply the demand, and if the people could be brought to realize the profits in the industry a material improvement would certainly be brought about.

The fact that the climate of North Carolina is so mild that cattle do not have to be stabled only a short period during the year is a decided advantage. Another and very important consideration is, that cottonseed meal, one of the richest dairy feeds, is produced here and can be purchased by the dairymen of North Carolina much cheaper than by the dairymen in the States farther north. Furthermore, leguminous crops grow remarkably well here and there is more corn being grown every year, which speaks well for the dairy possibilities. A growing interest in dairying is shown by the large number of new silos constructed during the past few years.

To improve and develop the dairying of the State in a substantial way, those interested must go about it in a careful, systematic manner, using good sound business methods and keeping careful records of all details. It is the purpose of this bulletin to make suggestions and to demonstrate, if possible, whereby the dairyman can feed and manage his dairy herd in a profitable manner.

Selecting a Good Dairy Cow.

To select good high milk producing dairy cows requires experience and a careful study of cows. The best judges make mistakes at times, but there are certain well defined rules which, if carefully followed, will prove satisfactory in the majority of cases. First of all, it must be considered what constitutes a good dairy cow. The dairy cow is an animal that has been developed to produce milk and butter economically. The most economical producers as a rule show a characteristic dairy type known as the triple wedge form. All of the breeds of dairy cattle conform to this type in a general way, although they may be radically different in breed characteristics. Typical dairy animals are angular and muscular, rather than smooth and evenly fleshed. Experience teaches that the lean, clean cut cows showing quality in thin mellow hide, fine hair, and bone, are the most economical producers as a rule, provided they have a good feed capacity, strong constitution, and a well developed udder. These essentials are too often ignored in the selection of cows for dairying purposes. To be a producer a cow must be able to consume, and this ability is best shown in the cow that possesses the deep, well sprung middle. To produce economically she must possess a lean, clean cut character, showing that she is turning her feed to good account in milk and butterfat production. To be able to feed heavily and consistently, a cow must have a strong constitution, shown by a deep full chest, which allows ample room for her heart and lungs. A well developed pelvic arch is also desirable, as it gives a cow strength where strength is needed in supporting weight, and ample room for her reproductive functions. A cow may possess the essentials of feed capacity, constitution, quality and form, but lack in udder development and thereby become an undesirable cow from a dairy standpoint. To be an efficient producer a cow should have a large, well developed, soft, pliable udder which helps to complete the dairy structure. The most desirable udder is one that fits rather closely, being evenly balanced, extending well up between the thighs, and well forward on the belly, with teats of uniform size placed well apart to allow easy milking. The typical dairy cow shows greater depth and thickness through the rear portion of the body than through the front. This is necessary as greater space is required for a well developed digestive system than for a well developed respiratory system. This gives the cow a wedged appearance as viewed from both side and top. The third

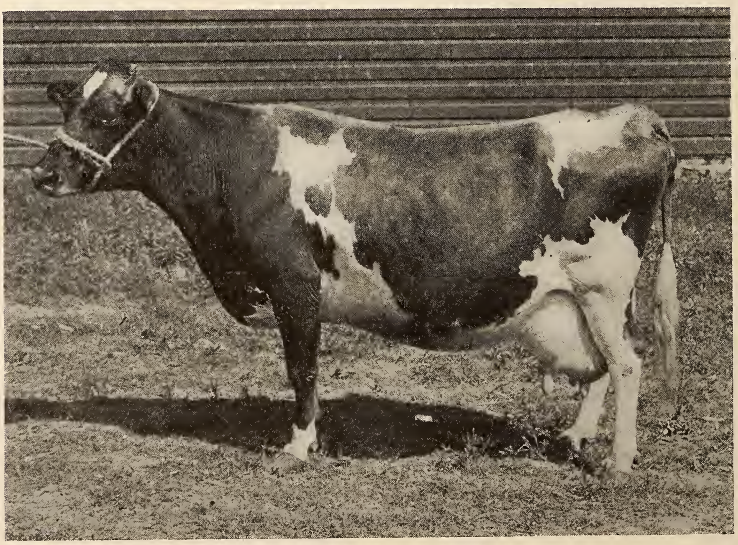

FIG. 1—Grade Jersey cow showing the typical wedge form from the side. A splendid feeder and producer.

wedge of the triple wedge indicates refinement and constitution, the point of the wedge being the thin sharp withers and the base, and the broad, well developed chest.

FIG. 2—Grade Jersey heifer lacking in feed capacity and constitution as shown by shallow, thin body. A light feeder and poor producer.

In selecting a dairy cow avoid the one with a thin narrow head, small muzzle, weak jaw, narrow chest, with legs set close, and feet pointing outward, and short flat ribs, for such cows do not possess the capacity or strength for heavy production. They will prove as a rule

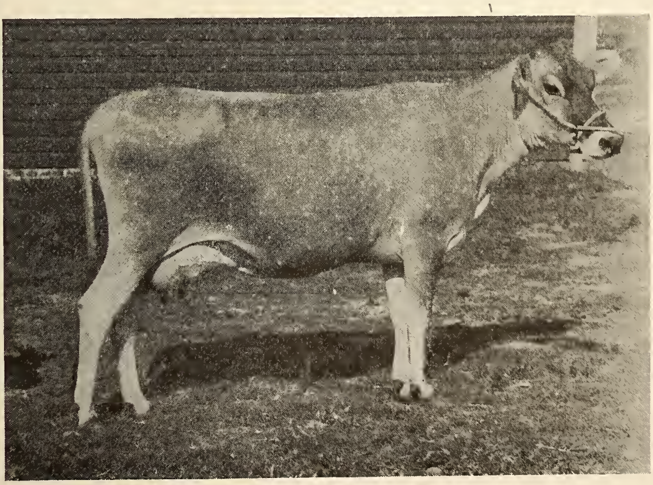

FIG. 3—Three year old Jersey heifer showing good dairy type. A good feeder and excellent producer. Record for 120 days was 3371.8 pounds of milk and 181.8 pound of butter.

to be weak, poor feeders, and consequently poor producers. Also avoid the one that possesses a short, heavy masculine head and neck, thick fleshy shoulders and coarse withers. Such cows often use a large portion of the food supplied them in putting flesh upon their own body rather than for producing milk and butter economically. Figures 3 and 4 demonstrate clearly the difference between a Jersey heifer, showing good dairy form, and another of the thick fleshy type which shows considerable masculinity in having a short heavy head and neck. The records of these two heifers brings out clearly the ability of the one showing the dairy type to produce milk and butter, while the record of the other is just about what we could expect considering her conformation. Both heifers have been kept under favorable conditions and have been well fed. While one has been making a splendid profit the other has barely paid for her feed.

Feeding Dairy Cows.

The cost of keeping a mature dairy cow in the various States ranges from $42, as reported by some of the Middle Western States, to $80 to $90 per year in some of the Eastern States. This wide range in cost is due to the range in price of feeding stuffs in the various States and to the length of time which the cows must be confined to the stable. Good permanent pastures also greatly reduce the cost of maintaining a herd. There is no phase of the dairy industry that requires more careful attention than the feeding. Neglect and oversight on the part of the feeder will often greatly reduce the profits if not make the herd unprofitable. In feeding the dairy cow it must be borne in mind that the feeding of the animal is for the production of human food and that to secure best results she must receive foods she can handle economically and produce a maximum amount of milk from them.

The balanced ration which has come to be quite generally known is meant one from which the animal receives sufficient quantity of each nutrient of the food so that it can maintain itself and do satisfactory work in addition. The work in the case of the dairy cow is the production of milk and butterfat. The work of the draft horse is hauling. With the sheep, it is growth of fleece or flesh. For the pig growth or fat production, and the beef steer meat production. In other words a ration can be balanced so as to meet the requirements of any animal or class of animals.

It is a well known fact that plants in some form or other form the bulk of the food of domestic animals. For plant growth certain conditions are necessary, such as light, heat and the presence of available plant food in the form of various combinations of elements in solution in the moisture of the soil. The roots of the plant absorb this plant food in the form of sulphates, phosphates, chlorides and nitrates, taking it up through the stems until it reaches the leaves where, by the aid of the sun and the peculiar structure of the cells of the leaf, it is broken up, reuniting with elements which come in through the leaves and then is stored as plant tissue which serves as animal food. Considering the plant from a food standpoint, it is found that the elements have been rearranged into what are known as the protein group, those containing nitrogen which are used in forming muscle, milk, wool, etc.; carbohy-

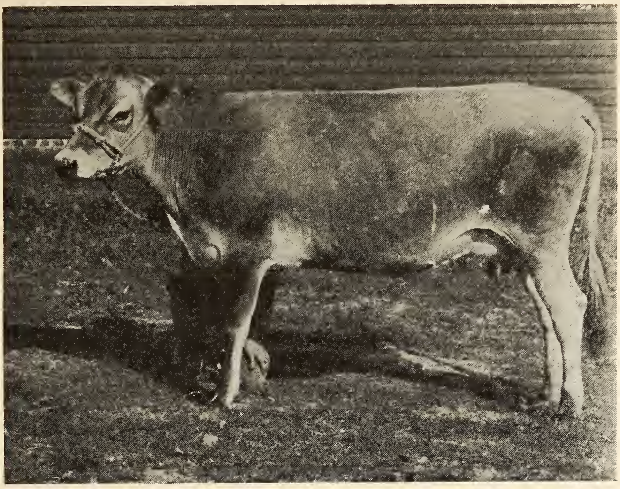

FIG. 4—Three year old grade Jersey heifer showing coarseness in a masculine head, neck and shoulders, and undesirable form of udder. Record for 120 days 1389.4 pounds of milk and 80.8 pounds of butter.

FIG. 5—Grade Jersey cow five years old shown eighteen months after calving. Record for one year, 9147 pounds of milk and 472.43 pounds of butter. A good type to select.

drates such as sugars and starches, which are used in keeping the body warm and forming fat; and those known as fats or oils which are used in keeping the body warm and for forming fat. These three—protein. carbohydrate and fat—are known as digestible nutrients. Other compounds are also stored in the plant such as water, which is usually found in large quantity in growing plants and mineral matter, found in small amounts and very important in the development of the bony framework of the animal.

In feeding animals it must first be considered that they require a certain amount of nutrition for maintaining their body. And if we are going to expect extra work from them we must supply enough extra nutrition to meet the demands upon the animal. For example, a dairy cow weighing 1,000 pounds must have .7 pound protein, 8. pounds carbohydrates and .1 pound fat to maintain herself without gain or loss when she is not milking and is at rest. When producing an average of 22 pounds of milk per day she must receive 2.5 pounds protein, 13 pounds carbohydrates and 0.5 pound fat, according to the German standard. The experience of the dairymen of the United States has demonstrated that dairy cows can produce satisfactory results when receiving less protein and slightly more carbohydrates than the figures mentioned, thereby lessening the cost of the ration somewhat, as carbohydrate foods are usually cheaper than those high in protein. The grains or the foods known as concentrates which carry a high per cent of protein and which can be used satisfactorily in feeding dairy cattle are cottonseed meal, distillery grains, brewers' grains, linseed meal, cowpeas, soy beans, gluten meal, gluten feed, malt sprouts, buckwheat shorts, buckwheat middlings, peanut meal and wheat bran. Those which carry a high per cent of carbohydrates and which can be used in feeding dairy stock satisfactorily are corn, wheat and wheat middlings, rye, barley, rice, sorghum seed and Kaffir corn. These feeds are commonly used alone for fattening cattle, but may be used in connection with the protein feeds for dairy stock. Among the coarse feeds rich in protein are the legumes, as the clovers, peas, beans and alfalfa which carry a high per cent of digestible protein, so are exceptionally valuable in feeding dairy cattle; as by their use we can avoid feeding so much high priced concentrated feed. The coarse feeds that carry a considerable percentage of carbohydrates and fat are corn fodder, corn stover and corn silage and practically all of the true grasses as timothy, orchard grass, oats, wheat, barley and rye.

To formulate a satisfactory dairy ration, a number of factors must be considered such as size of the cow, period of lactation and condition and ability to produce. Some important considerations to bear in mind in selecting feeds are variety, palatability and digestibility. A safe rule to follow is to always supply as much coarse feed in the form of silage and hay as the cows will clean up and then supply as much grain extra as is required to balance the ration and secure the desired results in production. An average size dairy cow will consume about 35 pounds of corn silage per day, and if this amount is fed she will eat from ten to twelve pounds of good hay in addition. With this as a basis in feeding, a very good rule to follow in grain feeding is to allow one pound of grain for every three pounds of milk produced daily or one pound of grain for each pound of butterfat produced weekly. For example, a cow producing four gallons of milk per day or ten pounds of fat per week should be given ten pounds of hay, thirty-five pounds of corn silage and ten pounds of grain. In making up the grain ration it is desirable to use a combination of three or four grains mixed in right proportion so as to balance up the ration to meet the requirements. Variety is also secured by using three or four different feeds, which is quite a consideration in holding cows on feed for a continuous period.

Some good dairy rations are outlined below, the amounts to be supplied daily in two feeds:

1. Corn silage, 35 pounds; clover hay, 10 pounds; grain mixture, made up of distillery grains three parts, cottonseed meal two parts, wheat bran one part.
2. Clover hay, 20 pounds; grain mixture: wheat bran one part, corn meal two parts, oats one part, and cottonseed meal one part.
3. Peavine hay, 10 pounds; corn stover, 12 pounds; grain mixture: gluten feed two parts, wheat bran one part, and oats one part.
4. Corn silage, 25 pounds; peavine hay, 14 pounds; grain mixture: cottonseed meal two parts, corn meal two parts, wheat bran two parts.
5. Peavine hay, 15 pounds; dried beet pulp, 4 pounds (before moistening); grain mixture: cottonseed meal two parts, brewers' grains three parts, wheat bran one part.

It will be noticed that only clover and peavine hay were considered in the rations mentioned. Hay from the grasses can be used in feeding dairy cows, but it is not as desirable as good leguminous hay. The grasses do not carry the high per cent of protein that the legumes do and that is so essential for dairy cows. Corn silage is such a common dairy feed, it was included in a number of the rations. It is one of the best feeds that the dairyman can provide for his cows and enough should be put up to supplement short pastures as well as for winter feeding. Five to six tons provided for each cow will carry the herd through the greater portion of the year. If it is not possible to pasture it is very desirable to provide some green feed such as green rye, wheat, oats, and peas or corn. The fall sown crops like rye and wheat will furnish feed by the first of May. As a rule the wheat will be ready after the rye is gone. Canada field peas and oats sown on good soil in late February will make feed by the latter part of May, and by sowing at different periods green feed can be had for a considerable period in the spring. The clovers are often ready for feeding in May, and they make the best kind of green feed for dairy cows. As all growing plants carry a high per cent of water it is desirable to allow them to stand until they develop well so as to secure as much nutrition as possible, rather than feed them when immature when they carry a high per cent of water and are low in nutrients.

Corn Silage.—It is especially important to understand the development of the nutrients in the corn plant when putting up silage. In the past many people have made the mistake of cutting the corn too early, before the plants had time to mature a maximum amount of digestible feed. In such cases they have had silage of low feeding value. Others have been obliged for various reasons to leave the corn standing too long, so as to become dried out. Such corn does not carry sufficient water to make the silage moist enough to prevent rotting. If the corn is cut when it is well glazed with the stalk still green, and when put into the silo cut fine, evenly distributed and thoroughly packed, there will be very little loss providing the silo is tight and reasonably well constructed.

Corn silage is one of the cheapest and best feeds that the dairyman can provide for his herd, and if every dairyman in North Carolina could feed corn silage in liberal quantities, dairying in general would be more profitable and the average production of the cows of the State would be materially increased.

Herd Improvement.

Our breeds of cattle have been developed and improved by a few thoughtful men who realized the value of good stock. The dairymen of this State can materially improve the quality of their stock if they will go about it in a careful, systematic manner. It is a pleasure to note that there are a number of excellent herds in the State that have been developed by progressive, energetic men.

To improve and develop a good dairy herd much depends upon the herd bull and his ability to get calves that will mature into better cows than their dams. It is a common mistake among dairymen to think that it makes very little difference what kind of a bull their cows are bred to, just so they get with calf. Such ideas are largely responsible for the low average production of the dairy cows in many of our States. It is unreasonable to expect to secure strong, vigorous, healthy, high producing offspring from immature nondescript sires. There are entirely too many grade and scrub bulls scattered over the State for the welfare of the dairy industry, and until the people in general realize the importance of securing better breeding stock there is little hope for improvement. It is a common thing to find a yearling bull in active service, and perhaps he is given an opportunity to serve three or four times as many cows as he should rightfully have considering his age. Early breeding is responsible for loss in size and vigor very frequently.

Care and Management of Bull.

If it is necessary to use the yearling bull he should be well grown for his age before he begins service and receive the best of care from that time on. By the best of care is meant plenty of good, clean, substantial feed that will keep him growing and keep up his vigor. The ration should carry considerable protein and should always be sufficient to keep him improving. At first, one cow a week is sufficient and as he grows, develops and matures the number may be increased, if it is necessary, so that he may serve one or two a day when he is mature.

Sudden changes in the feed and extremes should be avoided. To keep the bull strong and vigorous he must receive regular exercise. This may be obtained in a small lot, by tread power or in running up and down under a strong overhead line. The tread power is responsible for many a good bull retaining his strength, vigor and ability to breed successfully until an advanced age. It is a common opinion among some that when the bull gets to be three or four years old he should be killed and a yearling take his place. Not so, he has just reached the period of greatest usefulness in his life if he is rightfully handled. Any one with good judgment can see where it would be advisable to secure the services of a tried, mature sire rather than take chances with an untried immature sire.

In feeding the herd bull it must always be remembered that to maintain vigor considerable nitrogenous food must be supplied. A grain mixture of oats three parts, wheat bran three parts, corn meal two parts and linseed meal one part, fed along with good leguminous hay and a small amount of corn silage will keep the bull in excellent condition. Some people think that the bull should get his feed from what the cows leave, but this is poor policy as the bull is going to have too much influence over the future of the herd to be treated in this way.

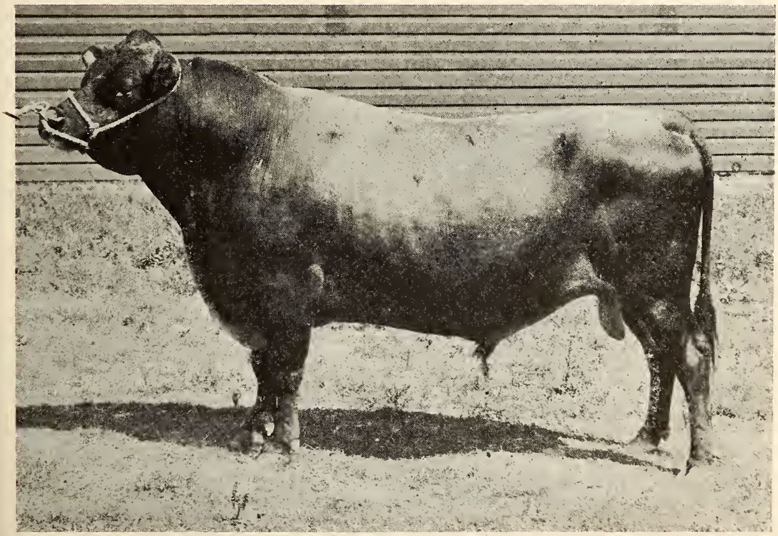

FIG. 6—Jersey bull, Eminent 19th, 78620, at four years of age. An excellent type of bull at the age of greatest usefulness.

Figure 6 shows the pure bred Jersey bull Eminent 19th in breeding condition. This bull has as fine a lot of daughters as can be found anywhere and the majority of them are out of grade Jersey cows. The uniformity of his get is something remarkable, yet is just what can be expected of a high class, splendid individual with such ancestry back of him.

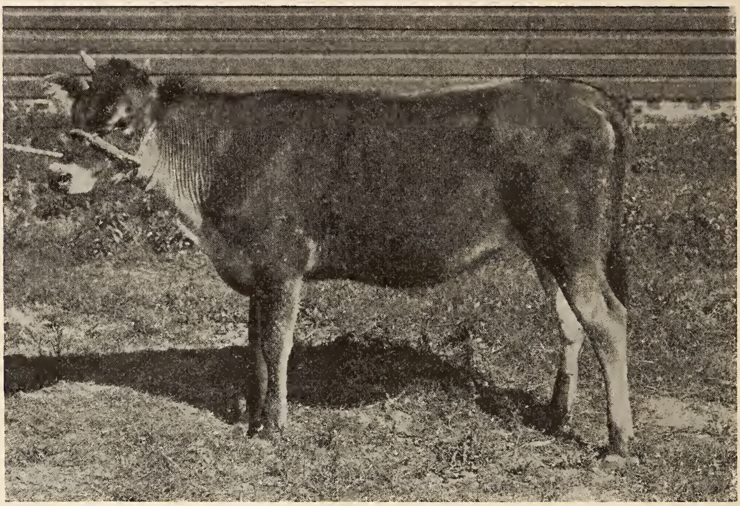

FIG. 7—Jersey heifer, Eminent's Nina, showing desirable form for developing into dairy cow.

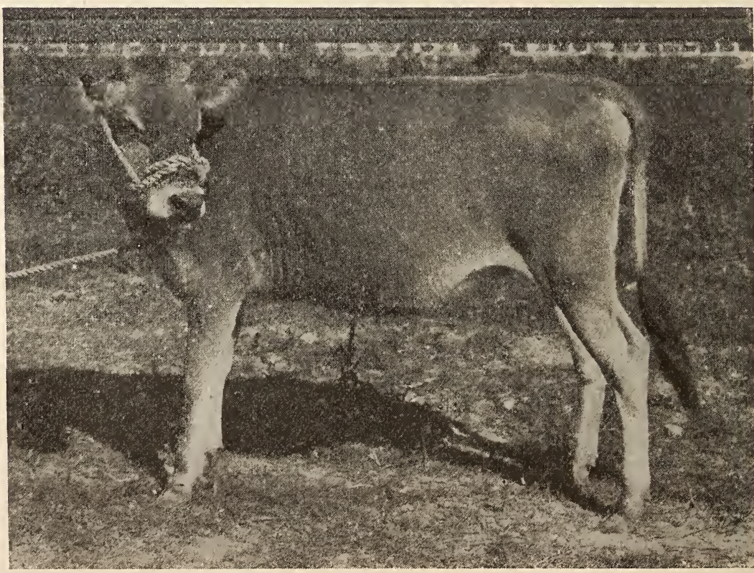

FIG. 8—Grade Jersey heifer by Eminent 19th, showing excellent form and dairy indications.

Dairy Calf.

Feeding and Management.—Some dairymen consider that they can not afford to raise their own cows and prefer to go out through the country and take their chances in picking up a good cow as they need one. The number of cows bought in this way that really prove to be worth their purchase price is very small. It is much more satisfactory in the long run to raise the cows for the dairy and in this way know the history of the animal and something about what can be expected in the way of production.

As a rule where milk is retailed the price is such that the owner considers it unprofitable to feed the calf on whole milk for any length of time, but it is advisable to make a little sacrifice at first for the welfare of the calf later on. If the calf gets well started there will be little trouble. There is no objection to leaving the calf with the cow for three or four days or until the milk is fit for use. The calf can be taken away then and placed in a separate stable if it is possible, as the cow will give less trouble if the calf is where she can not see it. By missing one feed, the calf will usually be hungry enough to be anxious to start to drink readily and will usually give little trouble when it finds that the bucket contains the supply. Four pounds of milk per feed fed three times a day for the first ten days will give the calf a good start when a small amount of skim milk may be substituted for a part of the whole milk, the amount of skim milk being increased so that when the calf is a month old, it is getting skim milk entirely. When the calf is two weeks old the feeds may be changed to two per day with the amount of milk increased gradually as the calf shows ability to handle it. As a rule when a calf is three weeks old it will begin to eat a little grain and it will usually be well to supply some to replace the butterfat removed from the milk. An excellent grain mixture for calves is one made of corn meal, oats, and wheat bran in equal parts with a little linseed meal added. To grow calves well they should have just what grain they will clean up readily at each feed. Plenty of green grass is good for growing calves, but if it is hot and dry or winter time a fine quality clover hay will produce excellent results. In addition to being nutritious, the clover hay carries considerable mineral matter which will help materially in developing the framework. Calves should have milk until they are at least five or six months old for best results. If they are forced to subsist on coarse feeds and grain too young they will be stunted, as their digestive system is not developed enough to handle such food, exclusively, at an early age.

A common mistake among some dairymen is to feed just what they happen to have to their calves instead of securing feeds that the calf can thrive on. In the Southern States cottonseed meal is commonly fed to calves, and it is one of the poorest feeds that can be given the young calf. If it does not prove to be fatal, it will be decidedly detrimental to thrift. The writer, in some feeding trials at this Station recently, has used cottonseed meal with other grains and has found that calves could not handle the meal satisfactorily until they were ten or twelve months old. In every case it proved detrimental to development where the calves were under ten months of age. This being true, it would be better to feed some other feed while the calves are young, such as oats, bran, and corn, which are known to be satisfactory. To secure good size the animal should continue to grow steadily until mature. If allowed to stop growing through neglect in feeding or other causes they become more or less stunted.

Fig. 9—The Jersey cow—G. M. K.'s Sylvia at ten years of age. Good dairy form and still doing good work in the herd.

Age to Breed Heifers.

As too early breeding of heifers is almost sure to prove detrimental to perfect development, it is well to allow them to get fairly well advanced before breeding for the first time. The dairy breeds vary in length of time required for maturing so it is necessary to breed some heifers later than others. Heifers of the Jersey or Guernsey breeds may safely be bred to drop their first calf when they are twenty-four to thirty months old, provided they are well grown. If not well developed, it will be advisable to give them a little more time. As the Ayshires and Holsteins are a little slower in maturing, they should be bred later, so as to drop their first calves when they are thirty to thirty-six months old. This will give them opportunity to develop into good sized useful dairy cows. With good care and management the cow should be able to freshen each year and continue to be a good producer until she is at least twelve years old. It is not at all uncommon to find a cow much older than this doing good work in the dairy herd.

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Agricultural Experiment Station

OF THE

COLLEGE OF AGRICULTURE AND
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WEST RALEIGH

PROFITABLE POULTRY RAISING

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
WEST RALEIGH, N. C.

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PROFITABLE POULTRY RAISING.

By J. S. Jeffrey.

In many cases those keeping poultry do not know whether they do so at a profit or a loss. In some cases poultry is kept by people who admit that they could buy their poultry and eggs cheaper than they produce them.

For those keeping only a few fowls and wanting fresh eggs no matter what they cost this kind of poultry keeping may be all right.

The poultryman keeping poultry for a living must have a profit for his work or it is only a matter of time till he will be obliged to change his occupation.

The farmer who keeps poultry should know whether he gets returns enough from them to pay for the feed eaten and the time devoted to them.

Whether poultry raising can be made profitable depends on a good many different conditions, but perhaps more on the person doing the work than on any other factor. Under average conditions as to cost of feed and value of the product, a person who understands the needs of fowls should be able to care for them so that they will return a good profit.

The most common cause of failure in poultry raising is lack of knowledge on the part of the person undertaking the work, and there is perhaps no other line of work in which it is so common for people to venture expecting success without any knowledge of the business.

On the farm a small flock can be kept and do fairly well with very little attention and feed, simply because the hens can find so much of their own feed on the farm. The same flock kept in a small yard and cared for in the same way would be practically non-productive. Even the farm flocks in many cases do not give the returns they might. The farmer overlooks the fact that his hens can not find nearly as much of their feed during the winter as they can in summer, and fails to supply them with something to take the place of what is lacking at this season.

For the best results it is necessary to have good stock, comfortably housed and properly fed.

Stock.

In order to get the best results in poultry raising, or in fact, in any line of live stock work, it is necessary to have good stock to work with. This is as true of farm poultry kept for the production of eggs and meat as of the fancier's fowls raised largely for exhibition purposes. The only difference is that the fowls are measured by a different standard. No matter what the stock is kept for, it should be the best obtainable for the use to which it is to be put.

What we keep poultry for, what conditions we have to keep the flock under, or our personal likes and dislikes, may make some difference in the variety we select, but there are some points which should be kept in mind no matter what variety is selected or what use is made of them.

No matter what variety is selected or what special branch of poultry keeping is engaged in, it is necessary to have strong, vigorous fowls if the best results are to be obtained. The weakling, no matter how good it may be in some other respect, should never have a place in the breeding pen.

In selecting a male to head the breeding pen, the first consideration should be vigor. He should be courageous, always willing to fight for and defend his mates, active and hustling, and should have a strong crow.

The hen should be active and busy, early off the roost in the morning, late in going to it at night, always on the move hunting for something to eat.

The variety or breed that is selected is not of great importance, but for certain conditions some are naturally better adapted than others. The farmer wants a fowl that is active enough to forage for a good part of its living. A large part of the profit which comes from farm poultry is made out of the waste products which the fowls find for themselves.

Fowls are naturally gleaners and scavengers, and while some may object to this latter term it is a fact that in many places they are kept to utilize waste products. On the farm under the best management this would consist of grass, grains wasted in the harvesting and insect life of different kinds found in the field. In other cases the hens forage in the stable, barn-yard, and manure shed. While there may be no objection to this latter for fowls whose eggs are used for hatching, it is not good practice if fine flavored eggs are wanted for marketing.

Many people, keeping a few fowls in a small lot, add greatly to the profit derived from them by utilizing the waste from the house. A large part of the ordinary kitchen waste can be used to good advantage for feeding fowls if it is kept in good condition and nothing put with it which would be injurious, such as tea leaves, coffee grounds or soapy water.

The farm fowls must still in a great many cases hatch and raise their own young, and this would eliminate the egg breeds such as Leghorns or Minorcas, which do not, as a rule, become broody. If, however, incubators are used and eggs are the principal product wanted, especially if there is a preference for white shelled eggs, these varieties will give good satisfaction.

For the average farm, where both eggs and market chickens are wanted, one of the general purpose breeds will probably give the best results. In this class we have the Plymouth Rocks, Wyandottes, Rhode Island Reds, and Orpingtons. Good stock of these varieties will be found to be good egg producers as well as making fine table poultry.

The town or small lot poultryman wants fowls that can be kept in small quarters and that stand confinement well. The Leghorns, being light, active birds, are hard to keep in small yards and high fences are necessary. On account of their active, nervous disposition they do not do as well under these conditions as where they have abundant range and the benefit derived from their good foraging qualities is lost.

Poultry Houses.

The question of poultry house construction is much simpler in our climate than it is in the North where the winters are much colder and where the fowls are confined to the house for long periods by the ground being covered with snow.

Under Southern conditions the house is very little used except at night and as a protection from storms and during very hot weather as a protection from the sun if other shade is not available.

The idea, which was prevalent a few years ago, that the house was to keep the fowls warm, has been very largely abandoned, and even in cold climates reports are being sent out showing that better results are obtained from fowls kept in cheaply constructed cold houses than from those kept in more expensive and warmer houses or in houses artificially heated during cold weather.

It must not be inferred from this that cold weather is ideal for egg-production; the better results in the colder houses not being due to their being colder, but because the other conditions are better, the house being dryer and having a better supply of fresh air.

There are a great many different kinds of poultry houses, many of which are quite satisfactory. No matter what kind or size house is built there are some conditions which should be observed if the best results are expected. Perhaps the most important of these is dryness. Fowls will not do well for any length of time in a house that is damp. Neither should they be confined on damp ground. Ground that is heavily shaded or so low that it is damp most of the time is much more difficult to keep free from disease germs than ground that is dryer. It is quite possible to have periods that are too dry for the best results either from the hens or chicks. During long, continued droughts, when green feed is scarce and dry, there is apt to be a scarcity of insect life, and unless special attention is given during such times there is very likely to be a falling off in egg production and the growth of the chicks will be checked. A range which provides both upland and low ground gives ideal conditions, as fowls will choose their own ground to suit the season.

Plenty of sunlight in the house is also necessary for best results, in fact it is not often that the house can be kept as dry as it should be unless the sunlight can get well through it. Sunlight is also a good germ destroyer, and the house should be arranged so that full advantage may be taken of this cheap means of disinfection.

Fresh air is also necessary, and the better results obtained from fowls in the colder houses previously referred to may be largely attributed to the better ventilation in these houses. It will be noted that all the houses illustrated are of the open-front type. The back and ends of these houses are made reasonably tight to prevent drafts striking the fowls, especially when they are on the roost.

The house should also be arranged so that it is convenient to work in and the appliances in the house should all be movable. Nests and roosts nailed to the wall make it difficult to fight mites and lice.

Fig. 1 shows a house which is giving good satisfaction at the Experiment Station. The back and ends are made tight and half the front is open. The opening is high enough to allow the sunlight to get well to the back of the house.

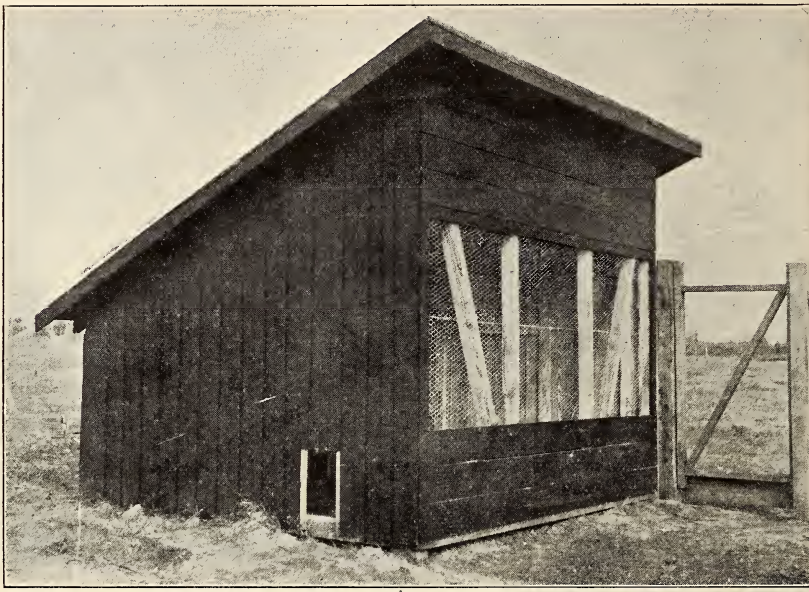

Fig. 1—Open Front Shed-Roof House.

Fig. 2 shows a double house of the same kind as the former. This can be used for two pens of fowls or for one larger flock. In either

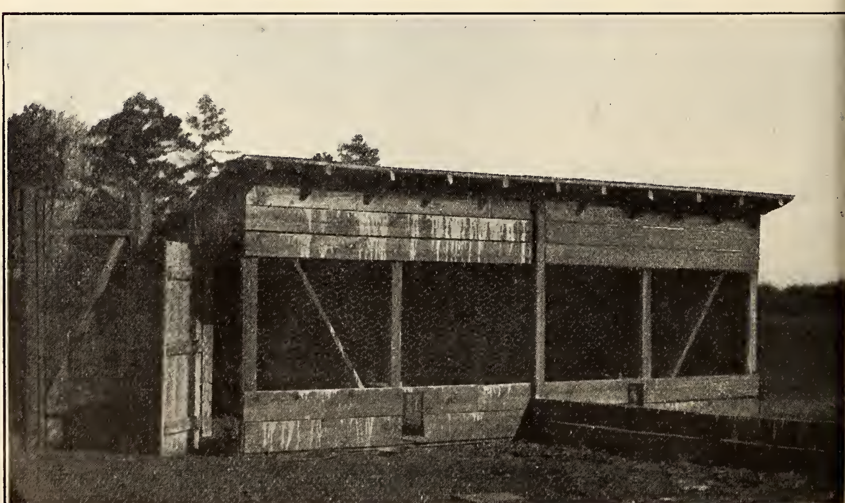

Fig. 2—Open Front Shed-Roof House for Two Pens of Fowls.

case the house should be divided by a partition in the center. If one large flock is kept in it the partition need not go all the way down to the floor, but may end just below the dropping board. The partition makes the house more comfortable by breaking winds which strike in at an angle with the front. Without the partition the wind will get to the back of the house on account of the long, open space, and part of the roosting room will be uncomfortable.

In Fig. 3 is shown a house that is quite popular in the North at present, and gives good results under their conditions.

For Southern conditions a higher front is better, as it admits more fresh air and sunlight through the house. The roof also is not as well adapted to our conditions as one giving less exposure to the south. The low front and long slope of roof to the south makes a very hot house in summer, and in our climate it is sometimes more difficult to keep the fowls comfortable in summer than in winter.

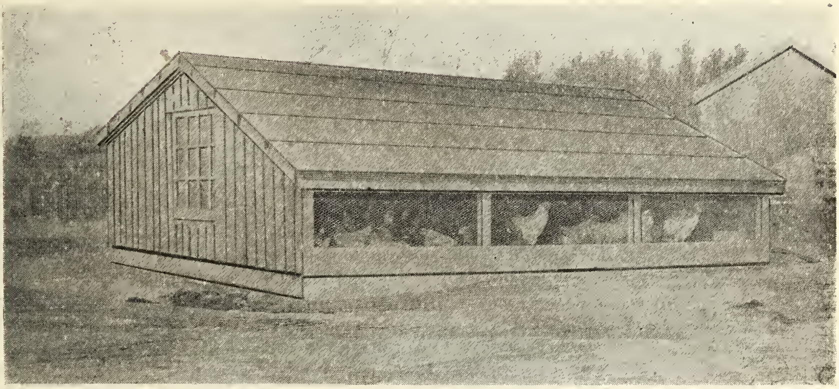

Fig. 3—Open Front House with Low Front. Photo by W. R. Graham.

In Fig. 4 is shown the same house as is shown in Fig. 1, with the top part of the back wall made as a door and opened for use during hot weather. This arrangement makes a much cooler house, but it has been found that at times the fowls do not like the draught in this house and roost under the dropping board to avoid it. A smaller opening near the top of the wall would probably give the necessary ventilation and avoid this objection.

A portable house is very useful on the farm. It can be used either for a pen of fowls or for a brooder house for chicks. It can easily be moved from place to place so that the fowls can have the benefit of fresh ground and good grazing.

The colony houses shown are made 10 feet by 10 feet, except the double house, which is 10 feet by 20 feet. The front posts are 8 feet high and the back ones 4 feet.

The portable house is usually made 6 feet by 8 feet and has a board floor. The floor makes the house stiffer, so that it stands being moved better than one without one, and also saves filling up the inside of the house with earth high enough to keep the floor dry.

In houses left in one place board floors are not recommended. A cement floor covered with sand or litter is the best, but on account of the expense is not often used.

A good floor can be made by raising the house high enough off the ground to give good drainage. Fill the house with a layer of stones and cover these with light loam or sand thick enough so that the floor is soft and the sand deep enough for the hens to dust in. The ground around the house should be graded to give a slope from the house in all directions.

Fig. 4—Rear View of House in Fig. 1. Showing Upper Half of Back Open in Hot Weather.

A floor of this kind can be kept in good condition by removing the sand a couple of inches deep each summer and replacing with fresh sand.

In an open front house the roosts should be at the back of the house so that the fowls will be as far away from the opening as possible. If a dropping-board is used it should be just high enough to allow the nests to be placed underneath it.

Fig. 5 shows the roosts hung on stop-lice hangers. When these are used the roosts are cut short enough so as not to touch the walls at either end. Holes are bored part way through the roost near each end, into which the hangers fit. There are small cups on the hangers, which can be filled with kerosene, breaking the connection between the wall and the roost.

Feeds and Feeding.

The feeding of poultry does not differ very much from that of other animals. They need the same food nutrients and, with the exception of the mineral or ash portion, in about the same ratio as is required for the dairy cow.

Small animals, which double their birth weight quickly, need proportionately more mineral matter than do the larger ones in which the relative gain is smaller. In the mammals nature has provided for this by increasing the amount of this element in the milk of the mother. While we have no data with regard to chickens as to just what percentage of ash should be in the ration, experiments have shown that rations containing a liberal amount of ash give better results both in development of the stock and in the production of eggs.

Poultry feeds may be divided into three classes, viz: grains and their products, green feeds and animal feeds.

In most cases the grains and their products form the larger part of the feed eaten by the hens, but occasionally we find on the farm at

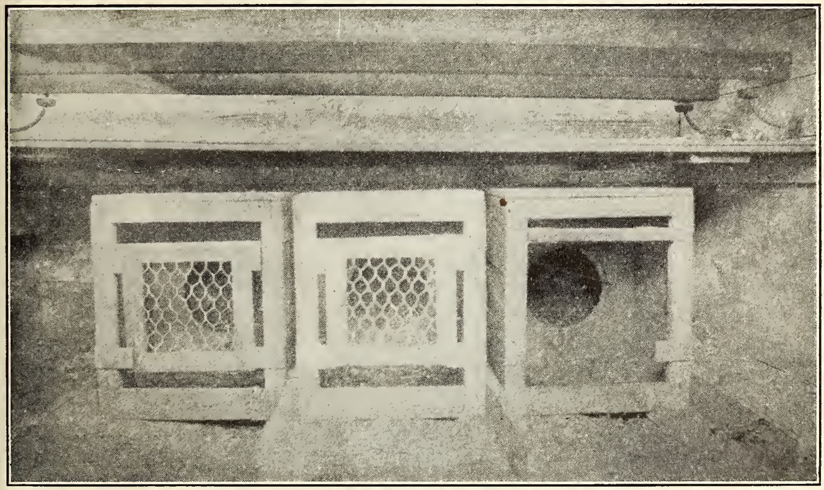

Fig. 5—Roosts Hung on Stop-Mite Roost Hangers.

certain seasons the hens getting practically all of their feed from the latter two classes, green feed and insects found in the fields forming the bulk of the ration.

The grains most commonly used for feeding poultry, in this section at any rate, are corn, wheat, and oats, and of these corn is more largely used than the other two together.

Notwithstanding the fact that the chemist tells us that corn does not contain nutrients in the proper ratio to make it a satisfactory feed for fowls by itself, it is found to be the principal feed used for poultry in many places where poultry is largely raised. This is especially true of farm poultry.

Corn, on account of its carbonaceous nature, is a better feed during cold than warm weather.

Some poultrymen, especially those feeding farm flocks, think this is not correct, because they find that where corn is the only feed given the hens they get eggs more plentifully during the summer. They overlook the fact that during the winter the hens are dependent on the feeder for almost their entire ration, while during the summer they can find a large part of it in the fields, and that what they get there is just what is needed to supplement and balance the corn ration.

Wheat is generally considered the best single grain for poultry. It is well liked by fowls and is not heating in its nature.

The price of good milling wheat is very often too high to permit of its being used for poultry feed. Good wheat screenings or wheat slightly damaged may often be had at a reduced price and can be used in place of the higher priced grain.

Oats are perhaps the best grain for feeding poultry, especially for the growing chicks. They are richer in protein and ash than either corn or wheat. On account of the large amount of husk they are not as palatable to the fowls as either corn or wheat and fowls that have not been accustomed to them do not eat them freely at first.

Crushed or ground and fed in a mash they are eaten freely. In some places they are the only feed given for the dry mash and good results are reported from their use.

The grain products most commonly used are corn meal, wheat bran, wheat middlings or ship-stuff and ground oats.

Green feeds are important, and if best results are expected they are a necessary part of the ration. On the average farm where only a few hens are kept it is not necessary to make any special provision for supplying this part of the ration during the summer, as the hens will find all they need if given free range. Fowls in confinement during summer and all fowls during the winter will benefit from a plentiful supply of green feed in some form which they relish.

On the farm the winter hay crops, such as oats, wheat or clover, will supply the needs in this direction.

Fowls can be pastured on these crops with no appreciable damage to the crop if care is taken to prevent their getting on it too early and it is not too heavily pastured.

In some of the lots at the Experiment Station these crops are used and twenty hens per acre pastured on them from the time they are well started till they are cut for hay with practically no loss to the crop except just around the house.

To utilize these crops the portable house previously mentioned is especially adapted, as it can be moved from place to place to suit the crops. For fowls kept in confinement, these same crops may be used if the yards are large enough so that the crop will not be killed out too quickly. A pen of ten hens and a male bird have been kept plentifully supplied with green feed from November to May on oats or rye in a lot eighteen feet by one hundred and sixty-five feet. The amount of space necessary will depend on the fertility of the soil and to a large extent on the season. It is always better to have the lot large if the necessary land is available.

If the fowls must be confined in small yards green feed may be supplied by giving cabbage, turnips or other vegetables. If only a few hens are kept there may be enough waste of this kind from the house or in many places vegetables which are unsuitable for household use may be procured at a low cost.

Where green feed is needed in larger quantities oats may be sprouted without much labor and at a low cost and make feed which is relished by the fowls.

In Fig. 6 is shown an oat sprouter in use at the Experiment Station. The drawers or flats are thirty inches square and two inches deep. The bottoms are made of galvanized iron, which is perforated to allow for drainage. Ten quarts of oats fill one of these drawers about one inch deep, and when sprouted till about three or four inches high will feed

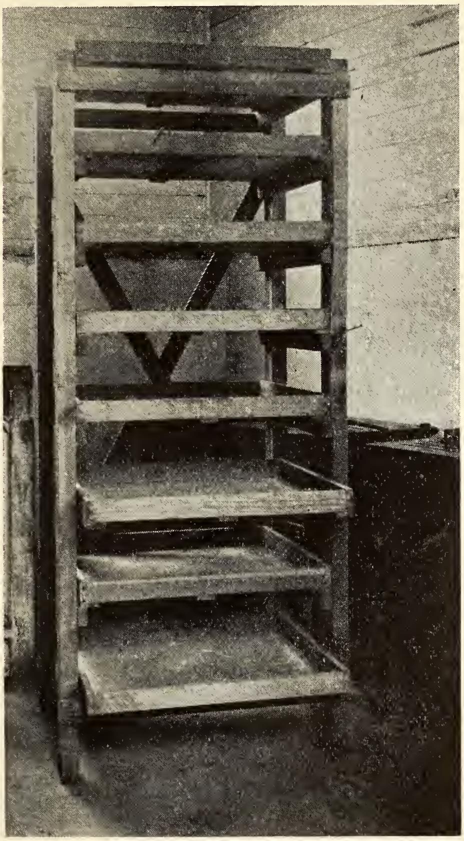

Fig. 6—Oat Sprouter Used at Experiment Station.

six hundred to eight hundred hens. With oats at sixty cents per bushel this would cost fifteen cents per day for the number of hens mentioned, which is perhaps as cheap as any form of green feed that can be supplied except on the farm where the fowls are scattered over a considerable area and do not injure the growing crop.

Animal Feeds.

Animal feeds are used principally for the protein and ash which they supply. Protein may also be supplied from a vegetable source. Cottonseed meal and linseed meal are the most commonly used feeds of this class and are largely used in feeding cattle, but they are not as well suited to poultry feeding as the animal feeds. They are not as well liked by the fowls and do not contain as much ash as is commonly found in the animal feeds used for poultry feeding.

Commercial beef scrap is perhaps more commonly used for poultry feeding than any other animal product. Good brands of this contain about 55 per cent protein, 12 per cent fat and 15 per cent ash.

Meat meal varies in composition and value, some commercial forms containing 60 per cent protein, while others may run as high as 85 per cent. The ash content is usually much lower in this product than in beef scrap.

Raw bone should contain about 25 per cent protein, and 22 per cent phosphoric acid. This is used in the form of meal and granulated bone, the former in the mash and the latter in a hopper for the fowls to eat as they wish. Meat meals that are deficient in ash can be improved by the addition of raw bone meal.

Green cut bone is used to advantage where a supply of it can be secured regularly without too much expense in getting and preparing it for the fowls.

On account of its nature it spoils quickly in warm weather, especially after being cut. This necessitates the getting of it frequently, and unless this can be combined with other business the expense of a special trip for the bone alone makes its cost high.

A mill is also necessary in preparing it for the fowls. For a small flock this adds considerable to the cost of equipment. For a large flock the labor in preparing it is considerable unless power is available.

The dairyman who is delivering regularly and who has power for his dairy work is in the best position to make use of this feed. Skim milk and butter milk can also be used to advantage in feeding poultry. They are equally good for the growing chicks and laying hens.

It has been demonstrated that for summer feeding at any rate skim milk is one of the very best feeds that we have for egg production.

Methods of Feeding.

The best method of feeding will vary with conditions. What might be the most economical plan for a man keeping only a few fowls on a town lot might be altogether out of the question for a farmer keeping one hundred or more hens on the farm.

It has been found that hens do better when fed a ration consisting of grains and of a mash made of ground grains and their by-products, and at times some animal food.

Formerly the common practice was to feed mash once a day and grain once or twice according to the conditions. In this way the mash was moistened with water or milk and fed in troughs, giving as much as the hens would eat clean in a short time. The objection to this plan is the labor involved. The mixing of the wet mash required considerable time each day in preparation and in feeding. If the feeder were not experienced the fowls would be apt to get too much; in which case the portion left over would have to be gathered up or be wasted. If too little were fed the egg yield would suffer.

Of late years many have adopted hopper feeding, in some cases the mash only being fed in this way and in others the entire ration.

The feeding from hoppers reduces the labor of feeding and thus allows the keeping of more poultry than could be looked after under the wet mash system of feeding.

The plan in use on many farms of feeding the hens grain once or twice a day will not give the best results, especially where the bulk of the grain fed is corn. Under this treatment we find eggs scarce in winter and plentiful during spring and summer, when they are low priced.

The supplying of a mash containing some animal food would in most cases greatly increase the egg yield and would give the increase at a time when eggs bring the highest price.

In the work of the Station we have tried to keep the rations as simple as possible and at the same time work out a system of feeding that would give good results without too much expense for labor.

The system that has been used with good results for the last year or two is as follows: Feed the fowls on a dry mash from a feed box or hopper which is open at all times. The grain is fed once a day and during the winter is scattered in litter for the hens to scratch out. During the hot weather the litter is removed from the pens and grain fed on the ground.

The grain is fed late in the afternoon at the time the eggs are gathered. Feeding at this time saves an extra trip which would be necessary if the feeding were done at another time. By delaying the feeding of grain till evening, the hens also eat more mash than they would if fed grain earlier in the day or if it were fed twice a day. It was found that the hens that only ate a small amount of mash did not do as well as those that ate approximately fifty per cent of the total ration as mash.

When there is extra good range for the stock it may be possible to get good results by feeding the entire ration from hoppers, but in most cases the hand-feeding of the grain will give more satisfactory results and if done as suggested above there will be very little extra time needed.

The feeding for egg-production might properly be considered under two heads, the production of eggs for market and of eggs for hatching. Rations which are quite satisfactory for the former are sometimes quite unsatisfactory when eggs are wanted to produce a good percentage of strong, vigorous chicks. It is generally thought that rations containing considerable animal food, while quite satisfactory as to the number of eggs produced, do not give the best results for breeding purposes.

Results obtained at this Station and published in Bulletin No. 211 show that skim milk fed in combination with corn and wheat and a mash of equal parts of corn meal and wheat bran, gave the best returns in egg production, but were closely followed by a ration in which meat meal and bone meal were fed in the mash in place of skim milk. A ration composed wholly of corn and corn meal with all the skim milk the fowls would drink also gave good results.

For the past year or two a portion of the Station stock has been fed on grain which was not marketable. The corn used was that shattered in the husking and shredding. The wheat was screenings. The corn was bought of the Station Farm at thirty-five cents per bushel, which was just half the price of good corn at the time. The wheat screenings were bought from mills in the neighborhood at a cost of $1.50 per 100 pounds.

Two parts of corn and one part of wheat constitute the grain ration and the fowls were given all they would scratch for each evening. The mash was made of 4 parts corn meal, 4 parts wheat bran, 2 parts meat meal and 2 parts bone meal. The mash was fed from feed boxes which were open to the hens at all times.

One pen each of Barred Plymouth Rocks and of S. C. Rhode Island Reds were fed this ration. At the beginning of the experiment there were ten hens and a male in each pen. One Plymouth Rock hen died and two hens and the male were disposed of from the Rhode Island Reds about June 1. The eggs laid, food eaten, cost per dozen of eggs, and profit per hen for the six months are shown in the accompanying table. Eggs are figured at two cents each, which is a fair average in the local market.

Breed	Eggs Laid	Food Eaten		Cost of Food	Cost of Eggs Per Doz.—Cents	Profit Per Hen
		Grain	Mash			
Barred Plymouth Rocks	833	243	243	$6.28	9.00	$1.038
Rhode Island Reds	833	232	224	5.87	8.45	1.079

The ration fed is the same as gave best results during the winter period as reported in Bulletin No. 211, except that the grains in this case were lower priced, as noted.

It will be observed that the grain and mash were eaten in about the same amounts. This bears out the results obtained previously where hens eating a liberal amount of mash did better than those that ate considerably more grain than mash.

Hatching Chicks.

On the farms of the State most of the chicks are still hatched by hens, and where only a few chicks are wanted this method will be found as satisfactory as any. Most people will raise better chicks with hens than by artificial means simply because they divide the responsibility with the hen. Experienced poultrymen do very well with the incubator, but chicks hatched in this way need constant care and attention.

For hatching for the early market and for large quantities of chicks for any purpose, the incubator is practically a necessity. For hatching the breeding stock the hen is preferred. If hens are to be set, a separate place should be provided where they will not be disturbed by the other hens.

Those that become broody and are to be set should be moved at night and handled carefully or many of them will refuse to keep the nest after moving.

If several hens are to be set at the same time the nests should be so arranged that the hens can be confined to them. A nest open to the front is preferred to one open on top, as there is less danger of the eggs being broken where the hen walks into the nest from the level of the floor than where she is obliged to get up on the top of the nest and then jump down on to the eggs.

When the nests are arranged and the hens become broody they are moved quietly after dark to the nests. A nest egg is given each and they are covered loosely with sacks to keep the nests rather dark. About noon the next day feed and water are supplied and all the hens are removed from the nests. They are allowed to do as they please for an hour or two, and those that go back are given the eggs they are to hatch. Those which do not return of their own accord are removed from the pen and broken up as soon as possible.

Those hens that are to be set are given a thorough dusting with insect powder and some is also sprinkled about the nest.

In our work pyrethrum powder has been found the most satisfactory. It costs more than most of the powders put up specially for the poultry use, but is more effective and there is less danger to the hen and chicks from its use. A second dusting should be given about the sixth or seventh day and a third on the eighteenth day. Do not leave the last dusting till the eggs are chipping or the hatch is apt to be injured by disturbing the hen and also by the insect powder injuring the chicks as they break the shell.

It may seem to some that three dustings require a lot of work and are unnecessary, but experience has shown that the time and powder used in this way pay good dividends in more and better chicks.

If the nest is to be used a second time it should be thoroughly cleaned out and the nesting material burned. The nest box should be thoroughly gone over with some good insecticide. A five per cent solution of one of the coal-tar disinfectants or ten per cent kerosene emulsion will give the desired result if thoroughly applied. Care should be taken to see that every part of the box is well soaked, both inside and outside, special attention being given to the cracks and corners.

If a number of hens are set at the same time, the eggs should be tested for fertility at the end of the first week and the infertile ones removed. If there are many infertile, those that are good may be given to some of the hens and the balance given a new lot of eggs.

Do not bother the hen at hatching time. The chicks are better left alone with the hen till they are twenty-four hours old.

It is difficult to give rules for operating incubators that will give good results with all makes. Differences in construction make necessary different methods of operation, and the place where the thermometer is kept will determine the degree of heat which it must register in order to get the best hatch. In most cases it is best to follow closely the directions for operating sent with the machine.

Some manufacturers recommend the use of moisture in their machines, while others make an advertising point of the claim that their machines do not need any.

It has been found in the work at the Experiment Station that under average weather conditions the use of a moisture pan helps the hatch in the so-called non-moisture machines as well as in those in which the makers recommend its use.

In most incubators, the moisture is supplied by a pan in the bottom in which wet sand is kept. Machines which ventilate through the side walls generally have the pan the full size of the bottom of the incubator. With machines that ventilate through the bottom this plan has to be modified somewhat in order not to interfere with the ventilation.

The pan should be made from three to six inches smaller each way, according to the size of the incubator, than the inside measure of the nursery. Place two one-inch square pieces from front to back on the bottom and place the pan on these. The pan need not be over one inch deep and should be from one-half to three-quarters full of sand, which should be kept wet. The pan should be put in when the hatch is started and taken out on the eighteenth day.

Thorough disinfection of the incubator just before the eggs are put in is recommended. Zenoleum and Chloro-Naphtholeum have both been used with good results. For this work a strong solution is used, it usually being ten per cent.

The egg tray is washed first, then filled with eggs ready for the hatch. The inside of the incubator is then thoroughly washed, the eggs put in and the door closed. The machine is always heated and regulated for the hatch before the disinfection.

Raising Chicks.

The chicks, whether hatched by the hen or in an incubator, need warmth and quiet the first day or two more than they do feed. Nature provides the yolk of the egg to feed the chick till it gets strong enough to hunt its own food, as it is obliged to do under natural conditions.

When the chicks are ready to move to the coop, it will be a good plan to give them a dusting with insect powder to make sure that they get a fair start. A good way to do this will be to use a shallow box for carrying the chicks and to sprinkle them liberally with the powder in the box. The surplus powder can be taken up and used for another lot. The hen also should be dusted at this time, as it is time wasted dusting the chicks if the hen is not free from lice.

A good coop for the use of the hen and chicks is the A-shaped coop shown in Fig. 7. This coop is easily made and affords good protection against the weather. The slats on the front should be wide enough apart so that the chicks can run in and out freely while the hen is confined to the coop. It will be good practice to keep the hen confined for the first two weeks instead of allowing her to run at large and carry her chicks wherever she likes. The chicks will grow faster and fewer will be lost if they do not range too far at first. These coops may be used either with or without a floor. In the early part of the hatching season when the ground is apt to be cold and damp, a floor is an advantage. Later on this may be dispensed with.

Make the floor separate from the coop, as it will be much easier to clean if this is done. Make the floor slightly larger than the bottom of the coop. When cleaning lift the coop off the floor, which can then be thoroughly cleaned and the coop replaced.

Fig. 7—A Shaped Coop for Hen with Chicks.

If no floor is used the simplest way to provide clean ground for the hen is to move the coop to a new place frequently. Water should be provided as soon as the chicks are put in the coop and a light feed may also be given.

The feeding of the chicks varies greatly in different localities and with different feeders. It is doubtful if any plan can be given which will give best results in all cases. The following has given good satisfaction at the Station plant: For the first three days, the chicks are fed rolled oats and hard boiled eggs in the proportion of four parts oats to one of eggs. The eggs used are those tested out as infertile. These are hard boiled and put through a meat chopper, shell and all, and are then thoroughly mixed with the oat flakes. If bread crumbs can be obtained they may be substituted for the oats. From the fourth to the fourteenth day, corn bread or johnny cake is substituted for the oat flakes. This is made of equal parts of corn meal and wheat middlings, and if possible mixed with milk instead of water.

The eggs may either be broken and baked in the bread or fed hard boiled. If baked in the bread one dozen (one and one-half pounds) should be used with three pounds each of corn meal and middlings.

Finely cracked chick feed is also given at this time. During this period the chicks are fed five times a day, three feeds of the grain ration and two of the bread and egg mixture, the first and last feeds for the day being of grain.

When the chicks are two weeks old a dry mash, the same as is used for the adult stock, is added and the bread and the eggs are gradually done away with.

The grain feed may be one of the commercial chick feeds or a home-made mixture. That fed at the Station is a home-made mixture consisting of two parts small wheat and one part each of finely cracked corn and the coarsest grade of steel-cut oats. The wheat is the smaller grains from the wheat screenings separated by passing it over a screen of one-eighth inch mesh. The corn is the coarsest part of home-ground corn meal. The oats were purchased from manufacturers of oatmeal. By the time the chicks are two or three weeks old, hulled oats are substituted, as they are cheaper and not too large for chicks of this age.

When the chicks are four to six weeks old they can be sorted and their feed from that time on will depend on the use that is to be made of them. Those to be kept for breeding stock should be given plenty of range and be fed to produce good growth. For this purpose use a mixture of equal parts of corn and wheat with a dry mash made up of four parts corn meal, four parts wheat bran, two parts meat meal and two parts bone meal. If good range is provided the meal may be omitted.

During hot, dry spells in summer, it is sometimes an advantage to give a feed of wet or moistened mash in addition to the above. This makes extra work, but the returns in growth and development will more than offset the cost of the extra effort.

If they are to be marketed as fryers or broilers, they should have less range and a more fattening ration. The object here being to put them in market condition just as quickly as possible.

In sorting the stock at this time, the farmer very often makes a very serious mistake in taking the largest and best developed chickens for market and keeping the smaller and poorer chickens for his own use. This may bring better money returns for the time being, but a few generations of this practice will bring the whole flock to the level of the culls.

Poultry Sanitation.

There is perhaps no branch of poultry work about which more questions are asked or information is more wanted than diseases. There is also no branch of work that it is better for the poultryman to keep away from than doctoring sick fowls.

Poultrymen throughout the country suffer heavy losses from disease at times not so much because they do not know how to cure disease as because they do not understand the principles of sanitation and the importance of preventive rather than of curative measures.

The treatment of diseases in poultry is unprofitable for two reasons: first, because if the attendant's time is worth much it usually costs more to effect a cure than the fowl is worth; and, secondly, because each fowl cured is usually returned to the flock and soon lost track of, and may produce offspring which are very apt to inherit the weakness which made the parent more subject to disease than were others in the flock.

The importance of sanitation has increased with the growth of the poultry industry, and further increases in the number of fowls kept will only intensify the importance of this subject.

Poultry sanitation may be considered under two general heads:

Houses.

In a previous chapter dealing with the housing of the fowls suggestions were made as to the kind of house most likely to be satisfactory, and attention was called to the necessity for fresh air and sunshine. The importance of cleanliness was also pointed out. There is, however, often a great difference between an ordinarily clean house and one that is clean from a bacteriological standpoint. This latter means not only ordinary cleaning but thorough disinfecting at least once a year.

Before disinfecting a poultry house it is important that it be cleaned thoroughly, removing all droppings, dust, cobwebs, and any litter that may be on the floor. If an earth floor is used enough of it should be removed until none of the litter shows in it. It is only after a thorough cleaning of this sort that disinfecting can be done to best advantage. In most Southern localities, at least, it is good practice to give a first spraying of kerosene emulsion. This emulsion is made as follows: Cut up and dissolve in one gallon of hot water one pound of hard soap or one and one-half pounds of soft soap. While hot stir in two gallons of kerosene and continue stirring till thoroughly emulsified and cool, usually 15 to 20 minutes. When ready to use add 17 gallons more of water. This makes a ten per cent emulsion, which will kill all the mites and their eggs that it comes in contact with. The emulsion may be applied either with a spray pump or whitewash brush, the former being preferable. Allow the house to dry thoroughly and spray with a three per cent solution of one of the coal tar disinfectants, such as Chloro-Naphtholeum or Zenoleum. When the house is dry again follow this with whitewash in which the same amount of the disinfectant is used. Particular attention should be paid to the nests, to the roost boards and to any places that are difficult to get at. The principal thing is to use a good disinfectant and plenty of it.

These same instructions will apply to the brooder house, the individual brooders and to the incubator, the only difference being that the brooder and incubator need more frequent disinfecting. Once a week is not too often to disinfect the brooder, especially if there are any symptoms of disease among the chicks.

The incubator should be thoroughly disinfected just before each hatch is started.

Soil.

While the house has been mentioned first, the ground is perhaps more often to blame for troubles, both with the chicks and with adult fowls. In fact, it is being recognized more and more that the condition of the soil can very largely make or mar success in poultry raising.

Failure to realize this and that soil originally in good condition for poultry raising may by misuse and neglect get into such a condition that profitable poultry raising on it is impossible is responsible for many of the failures that we have with poultry. While this condition becomes apparent more quickly and is more often found among flocks kept on limited quarters, such as a town lot, it is not by any means unknown among farm flocks.

Many people who make a success on the start with a few fowls very quickly get into trouble for which the ground is responsible when they increase their flock and do not take precautions to prevent the ground from being tainted from the droppings. Poultry benefits by crop rotation just as much as any other farm crop if it is made a feature in the rotation. The best way to keep the ground in good condition for poultry is to grow crops on it as well as poultry. If the land has already become unfit for raising poultry on, it will be best to give up this line of business for a time. The free use of lime and the growing of crops, with the necessary turning of the ground, are the best ways to freshen the ground and get it back into such a condition that it will be profitable to grow chickens on.

Chickens grown on ground which has become tainted generally have an unthrifty, sickly appearance, and in this condition are much more subject to disease. Chicks raised on the same ground for a number of years without precautions being taken to freshen it are usually more or less subject to gapes and roup, and in fact to any disease to which fowls are subject.

Another point which may very well be mentioned here is in regard to the disposal of dead animals, whether fowls or larger animals.

One of the most destructive diseases which we have in the South among poultry is limber neck. This trouble is attributed to the fowls eating decaying animal matter. Far greater losses have been reported to the Station this year due to this disease than to any other.

The most common source of the disease is a chicken that has gotten out of sight and died. The other chickens eat the carcass and the maggots which soon follow death. Care should be taken to see that any animals which die are removed and either burned or deeply buried.

A law of the State requires that all dead animals be buried or disposed of in such a way that they are not a menace to the health of the community. It also places a penalty on the killing of the buzzard. The Southerner has become accustomed to looking on the buzzard as a scavenger and to depending on him to do this work, and consequently the first mentioned law is very seldom complied with, while the second is fairly well kept.

The natural food of the buzzard is dead animals, and if deprived of this, he is driven to preying on live ones and has under these conditions been known to become a serious menace to poultry. There is no more active agency for the spread of some of our worst poultry diseases than the buzzard, and the sooner we become our own scavengers the sooner we will be free from this source of infection.

Farmers' Advantages.

The great bulk of the poultry raised throughout the country is raised on farms where it is only a small part of the investment. Poultry raising, however, under proper conditions, is one of the most profitable of the small industries. Statistics gathered in one county of New York State showed that for the money invested poultry was more profitable even than the dairy cow.

The farmer has a great advantage over the town poultryman in having abundant range for his stock where it should be able to get plenty of green feed and insects. Many farmers do not get as much advantage as they should from their conditions on account of a fear that the fowls will injure the growing crop.

Unless portable houses are used so that the fowls can be moved to suit the crops and conditions, it will be advisable generally to have a yard in which the flock may be confined when necessary. If portable houses are used yards will not be necessary. Fowls ranging on a grain crop just coming up will kill out a great deal of it, while if kept off for a month or two till the young plants get a good start they will not injure the crop if precautions are taken to prevent large numbers ranging on a small area.

Twenty hens to the acre may be pastured on a wheat or oat crop with no apparent injury to the crop if they are spread out in small colonies.

If two hundred were housed in one house with a range over a ten-acre field they would cause much greater loss.

The scattering of the flock in small colonies increases somewhat the labor of caring for them. The hopper method of feeding, mentioned above, is almost a necessity if the flock is kept in this way.

The greatest objection to this method is the difficulty of controlling any disease which may break out. In cases of this kind it is often necessary to confine the flock in yards for a time.

The farmer often suffers loss with his chicks because he has fallen into the habit of raising them year after year in the same place without taking any precautions to purify the ground between seasons. If only one place is available this may be kept in fairly good condition by the use of lime and by plowing and cropping between seasons. Even when cared for in the best possible manner, it is not as desirable as new ground or ground that has been used a season or two for growing crops.

Town Poultryman's Conditions.

The conditions and problems of the poultryman living in the city are somewhat different from those on the farm. In the city the poultryman is confined in most cases to comparatively small quarters and does not have the same chance to move his poultry to fresh ground that the farmer has. Under these conditions it is even more necessary to keep what land one has in good condition. If a garden is also wanted the land available might be divided into two lots, placing the house so that the fowls may be turned into either lot at will. This will give a chance to alternate the ground between the garden and the garden and the poultry, which will be of advantage to both.

The man living in town does not have the advantage of range for his fowls, but as he usually keeps only a small number the waste from the kitchen can be made to help out with the feeding. In many cases these waste products are warmed regularly for the poultry and mixed with corn meal and wheat bran. Where the flock is small this does not entail enough labor to make it unprofitable as might be the case if conducted on a larger scale.

In many cases the town man succeeding with a small flock makes the mistake of increasing his flock beyond the capacity of his yards. With the larger flock the kitchen waste forms such a small part of the feed as to be hardly noticeable and he finds that his larger flock is not nearly so profitable as was the smaller one.

It is quite common to find persons starting in a new place making a marked success at first and gradually doing poorer and poorer till complete failure is reached simply because the yards have been over-stocked and not kept in a sanitary condition.

BULLETIN 222 JUNE 1912

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

COTTONSEED MEAL AND CORN SILAGE FEEDING EXPERIMENTS WITH BEEF CATTLE

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

TRUSTEES OF THE A. & M. COLLEGE

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The Bulletins and Reports of this Station will be mailed free to any resident of the State upon request.

Visitors are at all times cordially invited to inspect the work of the Station, the office of which is in the new Agricultural Building of the College.

Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

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SUMMARY

Beef cattle fed on corn silage as the roughage portion of the feed in conjunction with cottonseed meal will not only use the meal more economically during a continuous feeding period, but they will finish in better condition and command a higher price than cattle fed on dry roughages.

Beef cattle fed on cottonseed hulls as the sole roughage in conjunction with cottonseed meal will make good daily gains for sixty to ninety days, but thereafter the rate of gain will be materially decreased at the expense of the proper finishing of the animal.

The results obtained from this experiment in Lots 1, 3, 5, shown in table IV, page 123, show that the cattle fed cottonseed hulls for roughage made an average gain of 2.26 pounds daily during the first two months of the experiment, while the third month, the average gain was .54 of a pound daily and the fourth month only .01 of a pound daily.

In all of the lots where corn silage was fed as a whole or part of the roughage, the daily gains were more uniform throughout the feeding period than the gains made by the lot fed cottonseed hulls. The least average daily gain made during the last month by any of the cattle fed silage was .64 of a pound against .01 of a pound for the lot fed cottonseed hulls.

The lack of the same finish in this lot fed cottonseed hulls as that produced by the other two lots in this phase of the experiment furnished sufficient evidence that the cottonseed hulls fed cattle were not making the best use of their feed during the latter part of the period. The average daily gain of the lot fed cottonseed hulls for roughage was 1.28 pounds against 1.69 pounds for the lot fed corn silage alone as roughage.

The cattle fed cottonseed hulls in Lot 1, and used in comparison with Lots 3 and 5, to duplicate the two former years work, made the least profit per steer; the cattle fed corn stover and corn silage the next greatest profit, and the cattle fed corn silage alone the greatest profit, each of these three lots having received the same quantity of cottonseed meal.

Where cottonseed meal is the only concentrate used the indications are strongly in favor of feeding beef cattle on corn silage alone for roughage or corn silage supplemented with a small amount of dry roughage, such as corn stover.

The average amount of cottonseed meal used per pound of gain was over one pound less with the lots fed corn silage and corn silage and corn stover combined as roughages in comparison with the lot fed cottonseed hulls for roughage. This fact is contrary to the results secured the two previous years which showed that it took less cottonseed meal to produce a pound of gain when it was fed with cottonseed hulls.

These results are entirely in accord with conditions, however, as during the longer feeding period used the third year, the silage-fed cattle continued gaining satisfactorily until the end of the period. Whereas the results show that when cottonseed hulls are fed as the sole roughage for a long period the gains during the latter part of the period will be greatly reduced, which thus increases the amount of cottonseed meal required for making a pound of gain.

The lots fed corn silage and corn silage and corn stover combined for roughage made larger total gains and greater average daily gains than the lot fed cottonseed hulls for roughage.

The cattle fed cottonseed hulls for roughage were when finished valued the lowest per hundred weight, those fed corn stover and corn silage combined were given the next higher value; and the lot fed corn silage the highest value because of their uniformity and better finished condition at the close of the experiment.

The indications from this experiment in Lots 2, 3, 4, given in table V, page 127, are that the heavy feeding of cottonseed meal is not productive of sufficient extra gain to pay for the cost of the additional meal used. The lot which received the smallest amount of meal in this phase of the experiment made the greatest profit per steer. However, the writer is not willing to make a definite statement regarding the most profitable amount of meal to feed daily until further experimental evidence is obtained.

The results obtained, however, show that some erroneous ideas have been prevalent regarding the maximum amount of cottonseed meal which may be fed. The steers in Lot 4 consumed during the preliminary period of forty days an average of 2.3 pounds daily and during the experimental period of 122 days 9.07 pounds daily. Including the four days which the steers were kept after the experiment was discontinued, they consumed on the average 1,244 pounds of meal each in the 166 day feeding period, or an average of 7.49 pounds daily during the combined preliminary and experimental period.

COTTONSEED MEAL AND CORN SILAGE FEEDING EXPERIMENTS WITH BEEF CATTLE

By R. S. Curtis.

The Beef Steer Ration.

In a previous bulletin, the results from a steer feeding experiment were reported in considerable detail. The results which follow in this bulletin are from experiments which are a continuation of those previously reported on beef cattle feeding. The problem which the writer considers of great importance to the beef cattle feeders of this State is a determination of the relative value of cottonseed hulls, corn stover and corn silage combined, and corn silage alone as roughages in combination with cottonseed meal. The results obtained from this year's experiments indicate more emphatically than ever the great value of corn silage as a supplementary roughage to cottonseed meal, not only in pounds of gain, but in economy of production and satisfactory finish on the animals.

While it is admitted that cottonseed hulls for a time prove to be a most efficient roughage, it must be admitted also that their efficiency decreases rapidly long before the cottonseed meal fed steer is in prime condition for market. This is one of the essential factors which should be corrected in Southern beef cattle feeding, and the striking results secured from feeding corn silage indicate that this feed is going to greatly increase the efficiency of cottonseed meal in the beef steer ration. Undoubtedly a longer feeding period is the most important requisite for successfully competing with the better conditioned cattle of other sections of the country. Practical cattle feeders have observed that where they must depend on local markets for the consumption of their product and cottonseed hulls are the sole roughage used with cottonseed meal, the one hundred to one hundred and twenty day feeding period is the most economical. Experimental evidence bears out this observation.

In the experiments this year an effort was made also to determine the most profitable amount of cottonseed meal to feed daily to beef cattle. The plan of the experiment made possible a preliminary determination of this matter. While the indications are that it is not the most profitable to feed the amount of cottonseed meal given to Lot 4 in this experiment, the writer hesitates to comment definitely on the subject until further trials are made. The one point of importance brought out, however, in feeding the heavy meal ration is that it gives practical feeders an opportunity to safely increase the concentrated portion of the ration without fear of harmful results. A great many feeders through irregularity in feeding and fear of detrimental results fail to get the returns from their cattle which they should because of the small amount of cottonseed meal used in the ration. The figures which will

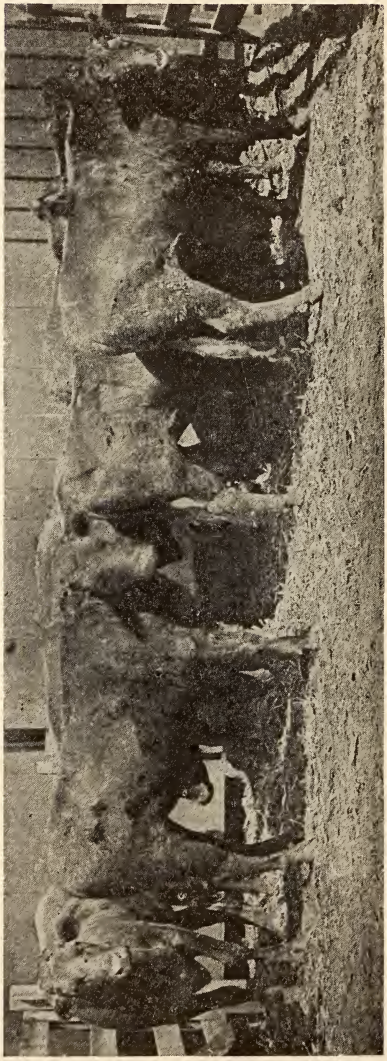

Fig. 1.—Cattle fed on 7.53 pounds of cottonseed meal and 26 pounds of cottonseed hulls.

be given later show quite conclusively that when corn silage is used in the ration the cottonseed meal may be materially increased over what is generally used by feeders and still remain clearly within the bounds of safety and profit.

Objects of Experiment.

The objects in conducting this experiment were in part the same as in the two former years, the results of which are reported in Bulletin 218; first, it was to determine the comparative value of cottonseed hulls, corn stover and corn silage combined and corn silage alone as roughage feeds when fed in connection with cottonseed meal; second, to determine the most economical amount of cottonseed meal to feed with corn silage and corn stover; and third, to determine the influence of corn silage in increasing the amount and in prolonging the period through which cottonseed meal could be fed safely and with profit.

Co-ordination of Work.

To fully understand the results of the experiment reported herein and to connect the results with those given in Bulletin 218, it will be necessary to show the relation of the experimental feeding period to the total feeding period each year. In the first year, fourteen days were given for the preliminary period and 112 days for the final period, making the total period 126 days; in the second year only four days were given for the preliminary period and 112 days for the final period, making the total period 116 days; while the third year forty days were given for the preliminary period and 122 days for the final period. Each year the length of the preliminary period was governed by the condition of the cattle. The last year an unusual condition arose in shipment, making it necessary to delay the experimental feeding until the time stated. During the preliminary feeding the last year, the cottonseed meal was increased quite rapidly in amount, especially during the latter part of the period, which in its effect on the steers was the same as though thee xperiments had been started considerably earlier in the period.

The point of special interest is in the work of the last year, in which the total feeding period was 166 days or five and one-half months. This is almost equal to the feeding period used in the corn belt, and yet during this time no ill effects from the meal feeding were apparent. While the final feeding period the third year was only ten days longer than in the two previous years, the prolongation of the experiments through the longer preliminary period, as before stated, demonstrated one point of great importance. This was that the maximum safe quantity of cottonseed meal that can be fed is considerably more than the amount ordinarily thought to be the limit. Second, when a long feeding period is to be used, though cottonseed hulls will be satisfactory for the first three months or thereabouts, the use of corn silage will successfully prolong the feeding period to a time making possible prime fitting of cattle for a discriminating market.

Plan of Experiment.

The experiment was planned primarily to duplicate the work of the two previous years, and secondly to determine the most economical amount of cottonseed meal to feed under the conditions herein given. The cattle were given a forty day preliminary feeding period before the experimental records were started on December first. The following outline shows the plan briefly.

TABLE I.—SHOWING THE KIND AND QUANTITY OF FEEDS USED DURING THE EXPERIMENTAL PERIOD.

Period.	Lot 1.	Lot 2.	Lot 3.	Lot 4.	Lot 5.
December 1, 1911 to March 31, 1912 122 days.	7.53 pounds Cottonseed Meal. 26 pounds Cottonseed Hulls.	6.05 pounds Cottonseed Meal. 12.70 pounds Corn Stover. 13.80 pounds Corn Silage.	7.53 pounds Cottonseed Meal. 12.70 pounds Corn Stover. 13.80 pounds Corn Silage.	9.07 pounds Cottonseed Meal. 12.70 pounds Corn Stover. 13.80 pounds Corn Silage.	7.53 pounds Cottonseed Meal. 30.60 pounds Corn Silage.

Lots 1, 3 and 5 are repetitions of experiments conducted during the two previous years. The daily cottonseed meal ration is the same for each of the three lots, while the roughages are the same in kind for each lot during the successive years and as nearly alike in the quantity fed each year as the individuality of the lots of steers would permit.

Lots 2, 3 and 4 show the variation in the quantity of cottonseed meal fed, this being six, seven and one-half and nine pounds approximately. This shows somewhere near the two extremes of feeding, the six pound ration or less being that used largely by the cattle feeders in the State; the seven and one-half pound ration represents about the maximum from the farmer's standpoint; while the nine pound ration stands clearly above the maximum under average conditions.

The roughage parts of the ration for these three lots were almost identical in amount to those used in the two previous years.

Shelter, Yards and Water Supply.

The conditions under which the steers were fed were the same as in the two previous years. The feeding barn was closed on all sides, except on the south. Extending from each 15 by 20 foot stall southward was a lot 20 by 80 feet to which the steers had access from the barn at all times. The water supply was constant, this being considered necessary for obtaining normal conditions.

Description of Cattle Used.

The steers used in the experiment were purchased in the western part of the State. They would class as medium-grade feeders, being very uniform in size, weight and quality. They averaged in the mountains

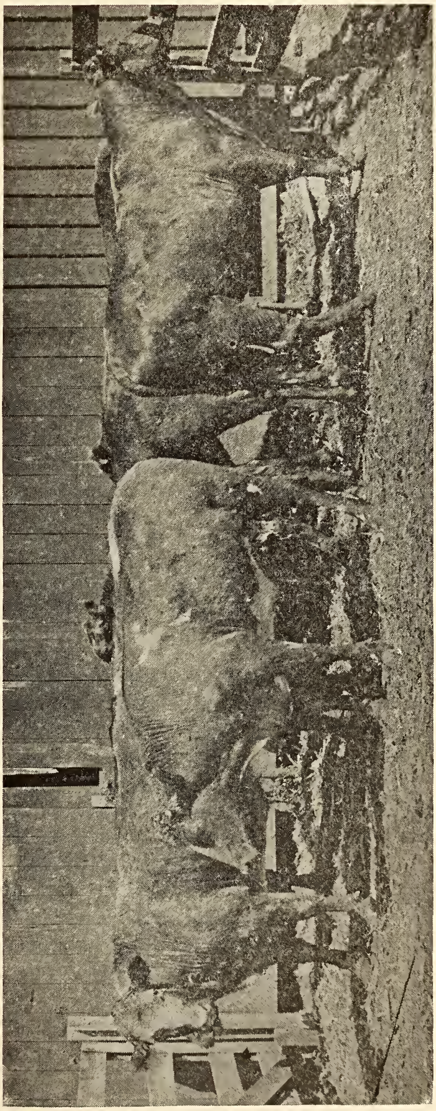

FIG. 2.—Cattle fed on 6.05 pounds of cottonseed meal, 13.80 pounds of corn silage and 12.70 pounds of corn stover.

slightly over 900 pounds, but owing to delayed transit, their shrinkage was very heavy which accounts for the long preliminary feeding period given to regain their normal weight and condition. The age of the cattle varied from two and one-half to three years. They were all grade Shorthorns with the exception of slight indications of Aberdeen Angus and Hereford blood in two or three of the animals.

While these cattle would not class as choice feeders, they were considerably above the grade used by most of the cattle feeders in the State. For experimental purposes they were very well balanced in type, quality and weight. An idea of their type may be gotten from the illustrations given herein.

Weights of Steers.

The steers were weighed when first taken to the farm and then at weekly intervals during the preliminary period to determine when they had regained their shrinkage. The experiment was deferred until December 1, when the initial weight for each lot was derived by taking the average of the weights for two successive days. Monthly weighings were thereafter made until March, when the steers were weighed in the middle of the month to determine when and the extent of the decrease in daily gains of the lot fed cottonseed hulls for roughage. The final weights were derived by taking the average of the weights made on two successive days at the close of the experiment.

Quality of Feeds Used.

The cottonseed meal used was the regular commercial product. The farm roughages were all of good quality although the corn silage was somewhat drier than usually put in the silo.

TABLE II.—SHOWING THE AVERAGE PERCENTAGE COMPOSITION OF FEEDS USED IN EXPERIMENT.

Feeds Used.	Water.	Dry Matter.	Ash.	Protein.	Carbo-hydrates.	Fat or Ether Extract.
Cottonseed Meal[1]	8.0	92.0	6.5	41.1	35.4	9.9
Cottonseed Hulls[2]	11.1	88.9	2.8	4.2	79.7	2.2
Corn Stover[3]	40.5	59.5	3.4	3.8	51.2	1.1
Corn Silage[4]	73.6	26.4	2.1	2.7	20.7	0.9

[1]North Carolina Experiment Station Chart, by C. B. Williams.
[2]Feeds and Feeding—Henry, page 567—tenth edition.
[3]Feeds and Feeding—Henry, page 568—tenth edition.
[4]Feeds and Feeding—Henry, page 572—tenth edition.

The feeds in every case were of the same nature as those used by the average feeder. While they were of standard requirements, in no case was the quality better than should always be used on the average farm. In table 2 is shown the average composition of feeds used in the experiment.

Valuation of Feeds.

The feeds used were given the following rating per ton: Cottonseed meal, $26.00; cottonseed hulls, $6.00; corn silage, $3.00; and corn stover, $10.00. The rating on cottonseed meal is about the average for the year. The corn silage and corn stover were figured somewhat higher and the cottonseed hulls considerably lower than for the two previous years. In making the rating on the roughage feeds in this way, every advantage is given to the cottonseed hulls which was the standard of comparison used in determining the relative value of the other roughage feeds.

Method of Feeding.

Preliminary Ration.—Because of the condition in which the cattle arrived at the farm, they were given an extra long preliminary feeding period. The first ten days the steers were fed nothing excepting roughage feeds. After that they were all fed twice daily on cottonseed meal, cottonseed hulls, corn stover and oat hay. The meal was gradually increased up to November 24, when each lot was placed on the respective kind of feeds to be used during the experimental period. No records were made, however, until December 1, when each lot was put on the total quantity of the rations to be used throughout the experiment. Because of the kind of rations and the way in which the preliminary feeds were given, the lot fed cottonseed hulls for roughage had the advantage over all the other lots. No change was necessary in their ration, either in kind or quantity of feed at the beginning of the experimental period. This makes the results still more conclusive regarding the comparative value of the dry and succulent roughage feeds.

Experimental Rations.—In Lot 1, the cottonseed meal was thoroughly mixed with the cottonseed hulls, while for the other four lots the meal was spread over the corn silage and mixed with it. The dry roughage was given in racks after the concentrates and corn silage had been consumed. It was noticeable, as in previous years, that the steers fed corn silage never left the feed troughs until the rations had been eaten. There was the same tendency to leave portions of the cottonseed hulls as in former years, showing that this ration was not as palatable as those containing corn silage.

The feeding was done regularly, morning and evening, water and salt being supplied *ad libitum*. All feeds were weighed excepting the corn stover which was measured in the racks, a determination having been made of the amount by weight the racks held.

Amount of Cottonseed Meal Fed.

During the first ten days of the preliminary feeding period, no cottonseed meal was fed, but after that, one pound of the meal was given to each steer daily, and increased so that at the end of forty days, each of the steers was receiving their full ration. The increase was made very gradual, to prevent an undue laxative condition in the steers. During the experiment none of the animals were off feed or out of condition.

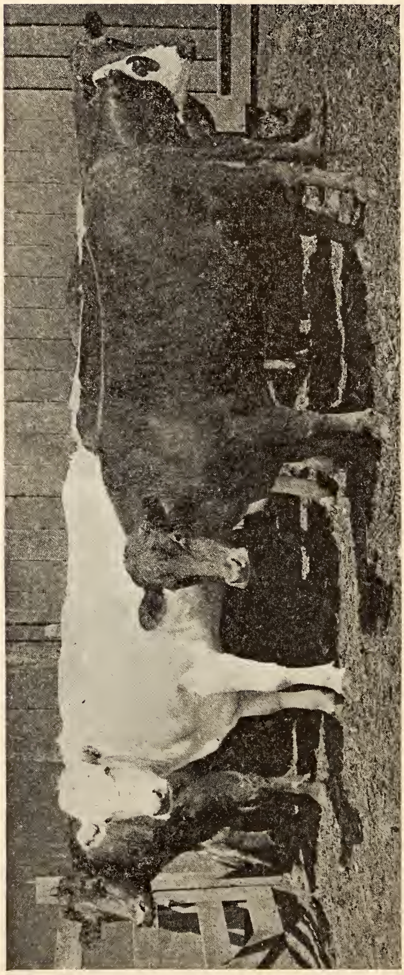

Fig. 3.—Cattle fed on 7.53 pounds of cottonseed meal, 13.80 pounds of corn silage and 12.70 pounds of corn stover.

TABLE III.—SHOWING THE AVERAGE DAILY AMOUNT IN POUNDS OF COTTONSEED MEAL FED PER STEER BY MONTHS, INCLUDING THE PRELIMINARY PERIOD.

Periods.	Days.	In 1911-1912.				
		Lot 1.	Lot 2.	Lot 3.	Lot 4.	Lot 5.
First ten days	10	----	----	----	----	----
First month	30	3.54	3.43	3.54	3.64	3.54
Second month	31	7.53	6.05	7.53	9.07	7.53
Third month	31	7.53	6.05	7.53	9.07	7.53
Fourth month	29	7.53	6.05	7.53	9.07	7.53
Fifth month	31	7.53	6.05	7.53	9.07	7.53
Average	162	6.28	5.15	6.28	7.49	6.28

After the rations once reached the maximum there were no changes made, each steer receiving the full amount daily thereafter, except as indicated below. At the close of the experiment the steers were all healthy, vigorous and gave every evidence of taking more meal if given an opportunity. While Lot 1 fed cottonseed hulls in conjunction with the meal was making no gains, they were apparently healthy and thrifty. The only change in the ration of this lot was the reduction of the cotton seed hulls from 28 to 20 pounds daily after their refusal to take the larger amount.

Average Daily Gains During Experimental Period.

One of the most striking facts brought out in the experiment was the effect of corn silage in prolonging the period through which profitable gains were made. The lot fed cottonseed hulls for roughage made the largest increase in weight for the first two months, but during the third month they dropped down to .54 of a pound, and the fourth month to .01 of a pound per day. In all of the other lots, the gains were made much more uniformly until the close of the experiment. In every case the silage fed cattle, made greater gains during the fourth month than was made during the third month by the lot fed cottonseed hulls.

TABLE IV.—SHOWING THE AVERAGE DAILY GAINS PER STEER BY MONTHS FROM BEGINNING OF EXPERIMENT.

December 1, 1911, to March 31, 1912. Period 122 Days.	Average Daily Gains Per Steer. In 1911-1912.				
	Lot 1.	Lot 2.	Lot 3.	Lot 4.	Lot 5.
First month	2.28	1.45	1.96	1.77	2.21
Second month	2.24	2.19	1.98	2.49	1.83
Third month	.54	1.56	1.67	1.33	2.09
Fourth month	.01	.64	.80	.94	.64
Average	1.28	1.46	1.60	1.64	1.69

The average daily gains of the steers as a whole from the time they were first placed in the feed lot until sold was a mere fraction under two pounds per day. The total average gain per steer for the 166 days was 322.6 pounds. It is important to note that during the experimental period the average daily gains made by the lot fed corn silage alone for roughage did not lack materially in making this average daily gain made by the entire number of steers during the total feeding period.

These results cannot be compared directly with those obtained during the two previous years because of the longer feeding period used in this experiment. Compared with the other feeds the results of this experibring out the fact, that cottonseed hulls may be used most profitably for a short feeding period. If cattle are to be fattened in high condition, however, corn silage will according to these results be a material aid in getting the greatest efficiency from the meal and in producing the most desirable finish on the animals. Where the largest amount of silage was used, the greatest daily gains were made, and the highest finish was secured at a lower cost per pound of gain than in any other lot.

Valuation of Cattle.

When the steers were first placed on feed the lots of cattle were all considered well balanced in value. They were of uniform weight and had been carefully selected as to quality and condition. The initial value assigned was the actual cost of the steers in the mountains. The final values were made by three disinterested parties who selected the lot fed cottonseed hulls as being the most inferior in finish and the lot fed corn silage as being the best both in uniformity of fattening and character of finish. The other three lots, fed corn stover and corn silage, were rated between the two lots mentioned above. There was very little difference in the condition of these three lots, however, if any, it was in favor of lots 2 and 3. The estimated values are considered very conservative, as they are based on the actual condition of the steers at the close of the experiment. Lot 1 had a dry, harsh condition usually seen in animals fed on dry unpalatable feeds. The other cattle, especially Lot 5, had a smooth, mellow finish due no doubt to the effect of the corn silage. By the use of this feed, which either defers the apparent toxic effect of cottonseed meal or greatly increases its efficiency, the feeding period was sufficiently extended to put on the characteristic finish of a well fattened beef animal.

Discussion of Results.

The results of the experiment with Lots 1, 3 and 5 are brought out by the figures given in Table 5. The total gains of each lot of cattle increased either as the corn silage or cottonseed meal was increased, the lot fed corn silage alone as roughage having made the largest total and average daily gains. While Lot 1 fed cottonseed hulls had the lead in average weight per steer, the steers of this lot were practically equaled in weight by those of Lots 3 and 5, at the close of the experiment. These results bring out clearly the advantage of having corn silage in the ration. They also demonstrate the fact that cottonseed meal and cottonseed hulls will, on the average, not likely produce profitable gains much beyond a 90 day feeding period.

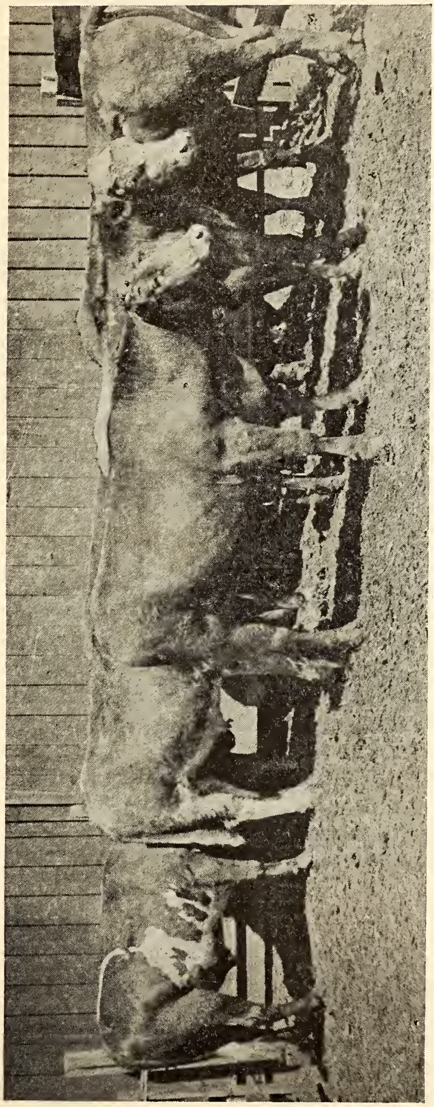

FIG. 4.—Cattle fed on 9.07 pounds of cottonseed meal, 13.80 pounds of corn silage and 12.70 pounds of corn stover.

In each case where corn silage was fed, in the three lots under discussion, it took over one pound less of cottonseed meal than where hulls were fed with the meal to produce a pound of gross gain. In the lot fed an all corn silage roughage it took approximately one and one-half pounds less of cottonseed meal to produce a pound of gain than for Lot 1 fed cottonseed hulls for roughage.

It is important to call attention to the fact that the results obtained in this regard were the reverse of those secured during the two previous years. With the longer feeding period used it took less cottonseed meal to produce a pound of gain when fed with corn silage than when the steers were fed cottonseed hulls. When cottonseed hulls are fed, the maximum gains are made in the early part of the feeding period, the gains being reduced materially in the latter part of the period. This shows why the cottonseed meal and cottonseed hulls ration generally give more favorable results during a short feeding period than otherwise. When corn silage is fed, the gains are maintained more uniformly until the end of the period on the same daily ration, and it requires less meal per pound of gain. While the results are apparently contradictory to those obtained the two years previous, when the effect of the corn silage and the difference in the length of the feeding periods are considered it can readily be seen how this condition would arise. This is the factor of economic importance to the Southern feeder, and from all indications corn silage is the one feed which is going to solve the difficulty of getting a prime finish heretofore not possible with dry roughage feeds.

The cost per hundred pounds gain was the least in case of the lot fed corn silage for roughage and the most for the lot fed cottonseed hulls for roughage, the cost for the lot fed corn stover and corn silage coming between the two. The lower cost of the gains in the lot fed corn silage and the higher value of the steers when finished made their profit more than double that of any other lot in the combined experiment. From these results the indications are that corn silage will almost replace cottonseed hulls pound for pound at practically one-half the cost for roughage.

While some cottonseed hulls were fed during the finishing period of all the lots fed corn silage not enough were used to cause any appreciable difference in the cost of gain or profit per steer in the silage fed lots.

TABLE V.—GIVING SUMMARY OF RESULTS FROM FEEDING BEEF CATTLE ON VARIOUS RATIONS.

	Experimental Feeding Period—December 1, 1911-March 31, 1912—122 Days.				
	Lot 1.	Lot 2.	Lot 3.	Lot 4.	Lot 5.
	Cottonseed Meal and Cottonseed Hulls.	Cottonseed Meal, Corn Stover and Corn Silage.	Cottonseed Meal, Corn Stover and Corn Silage.	Cottonseed Meal, Corn Stover and Corn Silage.	Cottonseed Meal and Corn Silage.
Initial value per hundred	$3.86	$3.86	$3.86	$3.86	$3.86
Average initial weight in pounds	945.7	919.3	893.6	905.	890.
Average final weight in pounds	1101.9	1096.9	1088.6	1104.8	1094.9
Total gain per steer in pounds	156.1	177.6	195.1	199.8	204.9
Average daily gain per steer in pounds	1.28	1.46	1.60	1.64	1.69
AVERAGE DAILY FEED PER STEER IN POUNDS.					
Cottonseed meal	7.53	6.05	7.53	9.07	7.53
Cottonseed hulls	*26.0*	*6.14**	*6.23**	*6.23**	*7.34**
Corn stover	----	12.70	12.70	12.70	----
Corn silage	----	13.80	13.80	13.80	30.60
AVERAGE AMOUNT OF FEED USED PER POUND OF GAIN.					
Cottonseed meal	5.89	4.16	4.71	5.54	4.48
Cottonseed hulls	20.30	4.21	3.89	3.30	4.37
Corn stover	----	8.70	7.92	7.73	----
Corn silage	----	9.50	8.61	8.41	18.22
COST, VALUATION AND PROFIT.					
Cost per hundred pounds gain	$13.74	$12.44	$12.54	$13.46	$9.87
Valuation of steers per hundred	5.50	5.75	5.75	5.75	6.00
Profit per steer	2.65	5.49	3.63	1.69	11.11

*Used during preliminary feeding period.

In Lots 2, 3 and 4 used to determine the most profitable amount of cottonseed meal to feed the results obtained are quite striking, although the evidence is not sufficient to draw any definite conclusions with reference to the matter. While Lot 4 was the heaviest at the close of the experiment and of the three lots made the largest total gains, the excess of cottonseed meal fed made the cost of gain higher and the profit smaller than in the other two lots. It took the most cottonseed meal to produce a pound of gain in the lot fed the largest quantity of meal and least in the lot receiving the smallest quantity of meal daily. The profit per steer was larger in Lot 2 fed the least quantity of meal daily while the next largest profit was made by Lot 3 fed the medium ration per day. While the figures in Table 5 give valuable indications, the results that will be secured in practice will depend on the cattle used, on the supplementary feeds and on the length of the feeding period. It is quite likely that the nine pound cottonseed meal ration would have been more effective had it been fed with corn silage alone. However, under the conditions of this experiment it did not so prove.

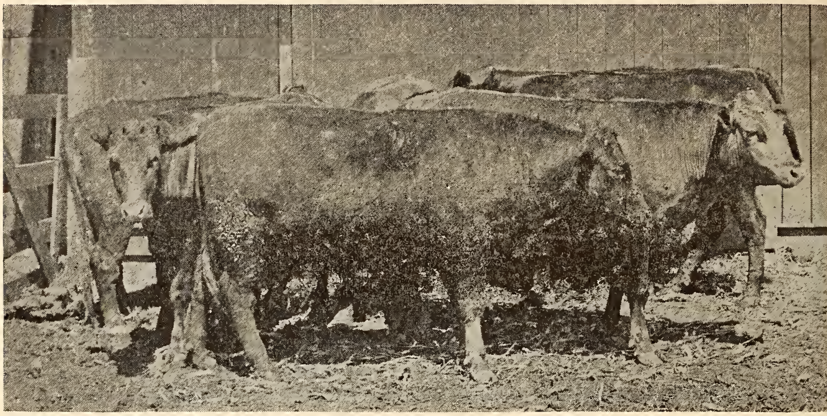

FIG. 5.—Cattle fed on 7.53 pounds of cottonseed meal and 30.60 pounds of corn silage.

The one fact of considerable importance brought out in connection with this heavy feeding was the absence of any injurious effects on the health of the cattle fed this quantity of meal. It shows that the maximum safe daily ration exceeds considerably the amount commonly accepted among cattle feeders. As the ration used by the average feeder is far below this, it indicates that whenever it is desirable for any reason to increase the amount of meal commonly fed it may be done without fear of injurious results.

Summary of Two Previous Years' Work.

The results of the two former years' experimental work in feeding steers are given in Table 6. The total gains made by each lot were on the whole very satisfactory. The average daily gain made by the steers fed cottonseed hulls as roughage were larger each year than the gains made by the other two lots. While it seems evident from these experiments that cottonseed hulls will produce very satisfactory gains for limited periods, the quality of the carcass was not as desirable, nor was the dressing percentage as high as that for the two lots receiving silage and stover.

The average daily gain made by lots 1 and 2 were practically the same. It will be noticed in Table 6, comparing the results of the two years' work, that it took less cottonseed meal to produce a pound of gain when fed with cottonseed hulls than when fed with corn silage, or corn silage and corn stover combined. The cost per pound of gain is very high, which is accounted for first, by the class of steers fed, and second, by the high cost of the cottonseed meal and hulls. If these results are compared with the cost of gains on steers fattened in the corn belt it will be seen that the figures given in the table are very high. If the average daily gains are compared it will be found also that the steers used in these experiments made approximately one-half the daily gains made by the class of cattle ordinarily used in the corn belt. It is evident, however, that if cottonseed meal remains at the present price, the cost of fattening steers will necessarily be high. It will necessitate a margin of at least $1.50 per hundred pounds live weight for cattle feeders to come out satisfactorily. It is possible, however, to reduce the cost of gains to some extent by using a grade of steers which will make larger daily gains. This is a very important factor as it not only reduces the cost of gain but it will increase the value of the finished product.

TABLE VI.—GIVING SUMMARY OF RESULTS FROM TWO PREVIOUS YEARS' WORK WITH BEEF CATTLE.

	November 6, 1909-February 26, 1910—112 Days.			October 12, 1910-January 31, 1911—112 Days.		
	Lot 1.	Lot 2.	Lot 3.	Lot 1.	Lot 2.	Lot 3.
	Cottonseed Meal, Corn Stover, Corn Silage.	Cottonseed Meal, Corn Silage.	Cottonseed Meal, Cottonseed Hulls.	Cottonseed Meal, Corn Stover, Corn Silage.	Cottonseed Meal, Corn Silage.	Cottonseed Meal, Cottonseed Hulls.
Initial value per hundred	4.00	4.00	4.00	4.50	4.50	4.50
Average initial weight	917.6	922.	946.7	915.6	915.2	899.5
Average final weight	1064.3	1072.9	1107.1	1061.5	1053.	1062.5
Total gain per steer	146.7	150.9	160.4	145.9	137.8	163.0
Average daily gain per steer	1.31	1.35	1.43	1.30	1.23	1.45
AVERAGE DAILY FEED PER STEER IN POUNDS.						
Cottonseed meal	8.14	8.14	8.14	6.77	6.77	6.77
Corn stover	16.52			20.80		
Corn silage	23.17	35.36		23.64	32.55	
Cottonseed hulls			17.92			21.60
AVERAGE AMOUNT OF FEED USED PER POUND OF GAIN.						
Cottonseed meal	6.21	6.04	5.69	5.20	5.50	4.65
Corn stover	12.61			15.93		
Corn silage	17.69	26.24		18.14	26.45	
Cottonseed hulls			12.52			14.90
COST, VALUATION AND PROFIT.						
Cost per hundred pounds gain	17.94	16.02	16.07	17.17	15.11	14.19
Valuation of steers per hundred	5.75	5.75	5.75	5.90	6.00	5.72½
Profit per steer	6.74	9.20	8.58	1.99	6.79	.31

In the first year, the steers were all sold at the same price. Even under these conditions, however, it will be seen that those fed corn silage made a larger profit than did any of the other lots, either the first or second year. While the steers were all sold at the same price the first year, the silage fed ones were finished better, having that firm touch characteristic of animals in good order. The lot fed cottonseed hulls was not as smooth. They had more of the harsh, rough handling qualities characteristic of animals fed a dry, unpalatable ration. While this ration was apparently relished, the large amount of crude fiber and the lack of succulence no doubt rendered it less digestible and consequently less efficient in producing a carcass of the best quality. Lots 1 and 2 were smoother than Lot 3, the hair being in much better condition and the animals, as a whole, being in much higher order. These observations were confirmed by the slaughter tests, made the second year. According to lots, the steers ranked in quality and finish as follows: first, lot 2, fed corn silage; second, lot 1, fed corn silage and corn stover; and third, lot 3, fed cottonseed hulls. While the distinction in price was not made the first year, the rank of the cattle in quality and finish was approximately the same as the rank given the second year.

Application of Results.

Two important problems confront the Southern beef cattle feeder. First, the difficulty of getting steers in prime condition on cottonseed meal for a discriminating market and second the difficulty of obtaining a margin sufficient to balance the extra cost of fattening when they are put in high condition. The former trouble may be met by using other concentrates than cottonseed meal, either at the beginning or end of the feeding period to offset the apparent toxic effect of the meal, especially when it is fed for long periods with dry roughages. Unfortunately, however, the feeds other than cottonseed meal which may be used for fattening cattle while putting them in prime condition so increases the cost of production that this method cannot be used by the practical feeder. The only practical and effective method so far demonstrated of finishing cottonseed meal fed steers in prime condition is by the use of liberal quantities of corn silage which has some specific effect in deferring the apparent toxicity and in obtaining the greatest efficiency from cottonseed meal. It is believed that with the three years results while differing in some minor respects, in the main some facts of importance to cattle feeders have been clearly brought out. The fact that a succulent feed like corn silage will materially increase the value of cottonseed meal to beef cattle feeders should place the South in line for the production of a large part of the Eastern supply of beef. This is now almost wholly shipped in from the middle West and Southwestern States, because the South has never produced the quantity to supply the demands of the more discriminating buyers. Cottonseed meal and corn silage with possibly some dry roughage will no doubt give more economical results in this State than any other feeds which may be used for fattening beef cattle.

Financial Statements.

The following financial statements are given for the purpose of showing results which may be expected in practical cattle feeding. The figures given represent the entire cost of the cattle and the feeds used. The weights charged against each lot are the mountain weights and represent the basis of settlement with the seller. While the figures given cannot be taken as absolute, because of the variation in prices of feed stuffs, locally, and from year to year, yet they do represent relatively facts which are of great importance to those farmers who are feeding beef cattle.

The manure credited to each lot is the amount actually obtained by weight, the total amount being 227 tons which valued at $2 per ton gave a credit of $454.

The profit made by Lot 4 is considerably lower than otherwise, owing to the small amount of manure obtained. This condition would have been overcome somewhat by crediting each lot with the same amount of manure. It was thought best, however, to credit each lot with the exact amount of manure produced as the conditions were the same for each lot during the experiment, and accurate weighings showed Lot 4 to have produced the least quantity.

Lot 1.—Seven Steers Fed Cottonseed Meal and Cottonseed Hulls in 1911-1912.

To purchase of 7 steers, weight 6420 @ $3.75 plus $1 per head	$ 247.75
To feeding 7126 lbs. cottonseed meal @ $26 per ton	92.63
To feeding 25308.5 lbs. cottonseed hulls @ $6	75.92
To feeding 770 lbs. corn stover @ $10 per ton	3.85
To feeding 2030 lbs. oat hay @ $20 per ton	20.30
Total	$ 440.45
By sale of 7 steers, weight 7713 lbs. @ $5.80 per hundred	$ 447.35
By value 47.19 tons manure @ $2 per ton	94.38
Total	$ 541.73
Profit on Lot 1 (7 steers)	$ 101.28
Profit per steer	14.44
Necessary selling price per hundred to break even on the transaction	5.71

Lot 2.—Seven Steers, Fed Cottonseed Meal, Corn Stover and Corn Silage in 1911-1912.

To purchase of 7 steers, weight 6440 lbs. @ $3.75 plus $1 per head	$ 248.50
To feeding 5840.8 lbs cottonseed meal @ $26 per ton	75.93
To feeding 7551.6 lbs. cottonseed hulls @ $6 per ton	22.65
To feeding 2030 lbs. oat hay @ $20 per ton	20.30
To feeding 11585 lbs. corn stover @ $10 per ton	57.92
To feeding 12740 lbs. corn silage @ $3 per ton	19.11
Total	$ 444.41
By sale of 7 steers, weight 7678.5 lbs. @ $5.80 per hundred	$ 445.35
By value 51.01 tons manure @ $2 per ton	102.02
Total	$ 547.36
Profit on Lot 2 (7 steers)	$ 102.95
Profit per steer	14.71
Necessary selling price per hundred to break even on the transaction	5.79

Lot 3.—Seven Steers Fed Cottonseed Meal, Corn Stover and Corn Silage in 1911-1912.

To purchase of 7 steers, weight 6330 lbs. @ $3.75 plus $1 per head	$ 244.37
To feeding 7126 lbs. cottonseed meal @ $26 per ton	92.63
To feeding 7630 lbs. cottonseed hulls @ $6 per ton	22.89
To feeding 2030 lbs. oat hay @ $20 per ton	20.30
To feeding 11585 lbs. corn stover @ $10 per ton	57.92
To feeding 12740 lbs. corn silage @ $3 per ton	19.11
Total	$ 457.22
By sale of 7 steers, weight 7620.5 lbs. @ $5.80 per hundred	$ 441.99
By value 50.86 tons manure @ $2 per ton	101.72
Total	$ 543.71
Profit on Lot 3 (7 steers)	$ 86.49
Profit per steer	12.36
Necessary selling price per hundred to break even on the transaction	6.00

Lot 4.—Seven Steers Fed Cottonseed Meal, Corn Stover and Corn Silage in 1911-1912.

To purchase of 7 steers, weight 6460 lbs. @ $3.75 plus $1 per head	$ 249.25
To feeding 8456 lbs. cottonseed meal @ $26 per ton	109.92
To feeding 7630 lbs. cottonseed hulls @ $6 per ton	22.89
To feeding 2030 lbs. oat hay @ $20 per ton	20.30
To feeding 11585 lbs. corn stover @ $10 per ton	57.92
To feeding 12740 lbs. corn silage @ $3 per ton	19.11
Total	$ 479.39
By sale of 7 steers, weight 7733.5 lbs. @ $5.80 per hundred	$ 448.54
By value 35.65 tons manure @ $2 per ton	71.30
Total	$ 519.84
Profit on Lot 4 (7 steers)	$ 40.45
Profit per steer	5.78
Necessary selling price per hundred to break even on the transaction	6.20

Lot 5.—Seven Steers Fed Cottonseed Meal and Corn Silage in 1911-1912.

To purchase of 7 steers, weight 6220 lbs. @ $3.75 plus $1 per head	$ 240.25
To feeding 7126 lbs. cottonseed meal @ $26 per ton	92.63
To feeding 8582 lbs. cottonseed hulls @ $6 per ton	25.75
To feeding 2030 lbs. oat hay @ $20 per ton	20.30
To feeding 770 lbs. corn stover @ $10 per ton	3.85
To feeding 27391 lbs. corn silage @ $3 per ton	41.09
Total	$ 423.87
By sale of 7 steers, weight 7664.5 lbs. @ $5.80 per hundred	$ 444.54
By value 42.11 tons manure @ $2 per ton	84.22
Total	$ 528.76
Profit on Lot 5 (7 steers)	$ 104.89
Profit per steer	14.98
Necessary selling price per hundred to break even on the transaction	5.53

BULLETIN 223 JUNE 1912

NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

OF THE

COLLEGE OF AGRICULTURE AND
MECHANIC ARTS

WEST RALEIGH

SHEEP RAISING

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THE NORTH CAROLINA

AGRICULTURAL EXPERIMENT STATION

UNDER THE CONTROL OF THE

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Address all communications to

N. C. AGRICULTURAL EXPERIMENT STATION,
West Raleigh, N. C.

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SHEEP RAISING.

By R. S. Curtis.

Adaptability of State to Sheep.

The sheep industry of North Carolina as now conducted represents one of the most backward and the least profitable lines of live stock husbandry followed in the State. The eastern portion of the State is not generally well adapted to growing this class of animals, however, on well drained farms under the most favorable conditions, the industry may be followed with quite satisfactory results. In the Piedmont section there is no doubt but what a large part of its waste land could be used porfitably for grazing sheep. Much of the hill and valley land now covered with coarse grasses and forest undergrowth would all furnish a large amount of pasture, and at the same time the land would be greatly improved in agricultural value. The western portion of the State, including the mountains and the upper Piedmont, are by far the best adapted of any section to sheep farming. This is true for two reasons chiefly: First, because of the high well drained pastures, thus giving comparative freedom from parasites, and second, because of the better natural grazing conditions. While it may be argued by some that the latter is unfortunate from the greater danger of the ravages of the stomach worm, yet from the standpoint of economical grazing this is not true. The stomach worm no doubt does a great deal of injury to sheep grown in this section, yet by proper pasturage methods a large percentage of this loss could be avoided. From the standpoint of soil, climatic and pasturage conditions no section of country could be better adapted to sheep than western North Carolina. While at present considerable portions of the rough land are utilized for cattle grazing there is still large areas of the rougher portions entirely unsuited to cattle which could be profitably used for sheep grazing. Even a great deal of that now used by cattle could be more profitably utilized in the production of sheep. For the amount of money invested and the quantity of feed required it is believed this class of animals will generally return a greater net profit than most any other kind of livestock that may be grown in the State.

Condition of Sheep Industry.

Two of the chief reasons for the scarcity of sheep are the presence of the cur dog, and the ravages of the stomach worm. There is no doubt but what great benefit would accrue to the farmers of the State if something were done to eliminate sheep-killing dogs, however, sheep may be raised profitably regardless of these enemies. Extra precaution to guard the flock from dogs, although it increases the cost of keep somewhat, will repay the farmer, providing the flock has been managed properly otherwise. Change of pasture is the most practical means of overcoming the ravages of stomach worms, which are especially dangerous to young lambs.

With the exception of a few sheep grazed on mountain pastures the writer is unable to locate any in the State except scattering flocks owned by some of the more progressive farmers in the Coastal Plain and Piedmont sections. Unlike the hog, a few of which are found on almost every farm, sheep are rarely given consideration. There are very few pure bred flocks in the State, the majority of them being crosses of various mongrel types. In the mountain pastures there is a reason for this condition existing since the character of the grazing land makes it impractical in many instances for the sheepman to give his animals daily attention. Even here, however, where pure breeds have been tried, they have proved highly satisfactory. Sufficient evidence has

Fig. 1—A flock of Western North Carolina ewes.

been obtained to show that many of the reasons given for not raising sheep are not well founded. Fair trials have shown that there is a place for improved sheep in the State. There is no good reason why the farms of the State should not support more than 214,000 sheep as at present, this representing only about one animal to every 146 acres, or an average of less than one sheep to each averaged-sized farm.

Briefly stated, the sheep industry is seriously neglected, although it is an occupation with great possibilities when handled properly. Even the use of a purebred ram would soon greatly improve upon the ewes seen in many of the farm flocks. The improvement that can be made upon ordinary ewes which can be purchased usually for three to four dollars per head would surprise the beginner and inspire confidence in the possibilities of the sheep business.

Adaptation of Breeds.

Naturally sheep are at home on high, dry and well drained lands. While the traits and characteristics of most breeds differ somewhat, and in some cases quite widely, it may be safely said that as long as sheep are kept on high and dry land, clean and well nourished, there is little likelihood of trouble. As an example of the peculiar traits of different breeds the Shropshire might be mentioned as a breed which is peculiarly adapted to the conditions existing on farms where natural pastures abound. The Black Faced Highland sheep are entirely different, choosing for their home some of the steepest cliffs on the mountain sides where a livelihood would seem well-nigh impossible. The Cheviot, while adapted to mountain conditions, does not choose the steepest and most rugged mountain sides like the Black Faced Highlands, but rather a more moderate condition of hills and cliffs. The Tunis on the other hand is well adapted to the lower and more level lands and to a warm climate, such as exists near the deserts of Africa, the native home of this breed. They can withstand more in this respect possibly than any other breed although like most other breeds they will thrive better under more favorable conditions of soil and climate.

Many other breeds might be mentioned, each having their own peculiar traits and characteristics. Sheep do not like wet feet, or foul places for feeding and sheltering. Such conditions are sure to bring on trouble and discouragement. Whatever the breed selected the animals should be given the high and well-drained places rather than the lower undrained fields. Under the latter condition troubles are likely to multiply either from intestinal worms, from diseases of the feet, or from constitutional ailments.

Sheep being ruminating animals can subsist largely on the coarser roughage feeds of the farm. They are great weed destroyers, often gaining a large part of their livelihood thereby, but they can not be grown to the best advantage without the addition of some concentrates during the winter or when on poor pasturage.

Sheep as Soil Improvers.

It is universally accepted that sheep droppings under like conditions contain a larger amount of fertility than that from either the horse, cow, or hog. One of the desirable features of this product is the uniform distribution made by the sheep over the land. In the leading European countries, such as England, Scotland, France, and Germany, the value of sheep in improving impoverished or naturally thin soils has been recognized for centuries. It is stated on good authority that many of the soils would be almost worthless but for the fact that they are densely covered with sheep. In these countries flocks of sheep aggregating two or three thousand in number are not uncommonly seen. The various breeds which naturally inhabit the rough mountain lands, and the precipitous cliffs of these countries, where only scanty and coarse herbage exists, manifest their great value in making otherwise worthless land bring in profitable returns.

Much of the gullied land and waste hillsides of this State could be utilized profitably in the production of sheep. Prominent farmers in the State have proved this to their highest satisfaction. Much of the land which now grows reeds and other coarse herbage can be restored to profitable tillage by the use of sheep. Fortunately the sheep is a ruminating animal and with the compound stomach can make use of much of the coarse grass and weeds which thrive on these depleted soils. In European countries where sheep raising is carried on extensively and usually profitably very little concentrated feed is used, except through the flushing and lambing season. During other periods hay, grass and roots form their mainstay. Any farmer who is willing to give to sheep the same amount of intelligent care that he gives to other livestock will find them not only profitable, but good soil improvers, bringing into cultivation large areas of otherwise waste land.

Important Breeds of Sheep.

Breeds of sheep are very numerous, these being adapted to a wide range of conditions, including the mountains, plateaus, and lowlands, with their varying degrees of moisture, temperature, and pasture conditions. The writer will only make mention of the types and important breeds giving a brief note regarding their adaptation. The following outline embraces these breeds showing their classification on a basis of wool and mutton types.

1. *Fine Wool Type—*
   Wool Production.
   - American Merino.
   - Delaine Merino.
   - Rambouillet.
2. *Medium Wool Type—*
   Mutton Production.
   - Shropshire.
   - Southdown.
   - Hampshire.
   - Oxford.
   - Suffolk.
   - Dorset Horn.
   - Cheviot.
   - Tunis.
3. *Long or Coarse Wool Type—*
   Mutton Production.
   - Lincoln.
   - Leicester.
   - Cotswold.
   - Kent or Romney Marsh.

While there are a few other breeds of sheep gaining greatly in favor in this country the classification just given embraces those now most universally accepted to be of standard type.

The fine wool type is used largely on the range for foundation flocks for lamb and mutton production and in those countries where fine wool growing is made a specialty, notably in Australia.

The medium wool class represents the average in length and fineness of wool, and is the type used largely for mutton production on arable farms, although this does not represent their limit of usefulness. The breeds of this class are generally adapted to the conditions of this State, however, in the mountains Merinos are quite largely used.

The long wool type includes the large breeds having long and rather coarse and open fleeces. They have not been used in the south to any considerable extent, as large breeds would not do well either in the rough mountainous section or even on level farms where pasture was not naturally available.

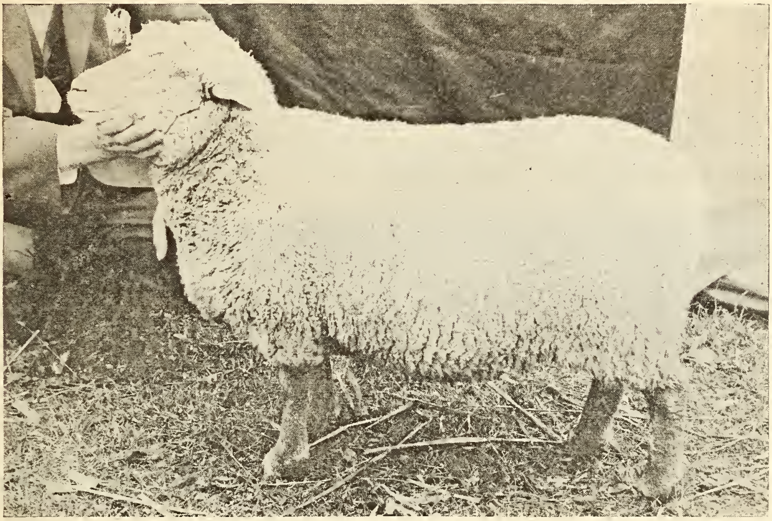

FIG. 2—A Southdown ewe from the mountainous section.

Of the breeds mentioned the Shropshires, Southdowns, Hampshires, Dorset Horns and Merinos are most popular in the State. They are all of medium weight and are good mutton producers with the exception of the Merinos which are used somewhat in the mountains of the State where the range conditions makes them of special value owing to the close, compact nature of their wool. Full or half-breeds of this type, especially when bred to rams of the mutton type, produce excellent lambs. This practice is followed very largely on the large sheep ranges of the west.

Feeds for Sheep.

In England and Scotland, in fact in most foreign countries, the ration of the flock is composed primarily of coarse feeds except during the lambing season and during the latter stages of pregnancy. Many of the rough feeds produced on the farm and the common weeds which infest the fields will be eaten readily by sheep. Hay, especially that made from the legumes, is well suited to them. Leguminous hay with the addition of concentrates in small quantities will carry a flock of ewes through the winter. Corn silage and annual pasture crops are all valuable.

The concentrates ordinarily used for sheep are corn, oats, soy beans, wheat bran, linseed meal and cottonseed meal. While the latter feed has not been used extensively in sheep feeding there are considerable data to show that it is a valuable feed for this purpose.

In the South where the grazing season is long and where so many annual crops can be grown and consumed both in the green and mature stage, there are exceptional advantages in sheep farming. Corn silage will take the place of roots, which are used very extensively by the English and Scotch flockmasters. The many weeds and coarse grasses annually growing in this section may be converted into money through sheep, and at the same time add yearly to the value of the land from the manure produced. These rough feeds and grasses should be utilized, and there is nothing more profitable in so doing than by the use of a healthy flock of ewes.

Pasturage and Succulent Feeds.

During the spring, summer and fall annual grazing crops can be depended on largely to furnish green feed for sheep. In the western portion of the State where permanent pastures thrive, they will be of great

FIG. 3. A field of rye and rape for sheep pasturage.

value in the economical production of sheep. During the winter a combination of grazing crops, and corn silage on farms where the latter is produced, will materially reduce the cost of maintenance. Rape should be included in the dietary. It is greatly relished by sheep and will furnish an abundance of green feed. However, it can be grown successfully only on fertile or well manured and carefully prepared land.

The following rotation is suggestive of what may be grown for sheep in this state. The particular crops produced will depend on the section in which the farmer resides. Some of the crops in the list may be unimportant in some sections, but they are mentioned for those who may be unable to grow the more important ones.

ANNUAL FORAGE CROPS FOR SHEEP.

Kind of Forage.	Amount of Seed per Acre.	Date of Seeding.	Period of Grazing.
Rape	3 pounds drilled 6 pounds broadcast	August 15 to May 1	Eight to ten weeks from seeding
Cowpeas	1 to 1½ bushels	May 15 to July 15	July 10 to October 15
Soy Beans	1 bushel	May 15 to July 15	July 15 to October 15
Canada Field Peas and Oats	1 bushel 1 bushel	February 15 to March 15	April 20 to June 15
Oats and Vetch	1½ bushels ½ bushel	August 10 to October 1	November 15 to April 20
Rye and Crimson Clover	1 bushel 15 pounds	August 1 to October 1	November 15 to April 25
Oats	1½ to 2 bushels	September 10 to November 15	November 1 to July 15
Wheat	1½ bushels	September 15 to December 1	November 20 to July 15
Rye	1½ bushels	August 1 to December 1	October 1 to April 20
Alfalfa	30 pounds	September 1 to October 15	May 20 to September 20
Red Clover	15 pounds	September 10 to October 15	April 1 to June 15
Japan Clover	25 pounds	April 1 to May 15	June 1 to September 15
Bermuda Grass	Rootstalks every second round of plow	March 15 to May 15	June 1 to September 15
Mangels or Stock Beets	6 to 8 pounds	April 20 to May 15	October 15 to March 1
Burr Clover	10 pounds clean 40 pounds burr	September 1 to October 1	December 1 to March 1

Shelter for Sheep.

Ordinarily the wool of sheep is a protection from cold, however, when they become wet through exposure to rain or storms it is likely to cause serious trouble. Aside from this need for shelter sheep could depend largely on a hillside or cove for protection. The buildings should be simple, durable and ample means should be provided for ventilation

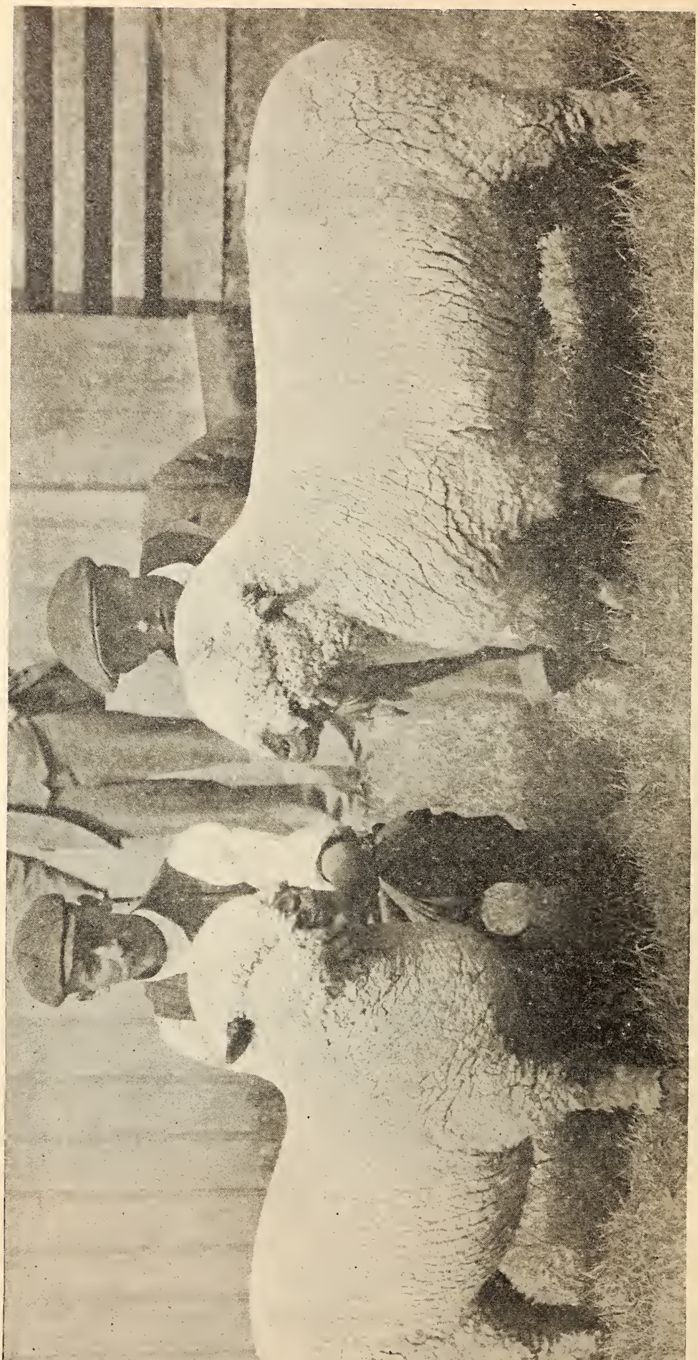

Fig. 4—A typical Shropshire ewe and ram.

and cleanliness. Sunshine in the buildings is important in order to keep them dry and thoroughly disinfected.

During the lambing season it will be necessary to take extra care with the flock. At this season the quarters should be adequate to provide for every need, although this does not necessitate expensive buildings.

Starting a Flock.

Pure Bred Flock.—In starting into the breeding of pure bred sheep the prospective breeder should first select the breed best adapted to his conditions, and then make selections from the flock of a breeder who has good stock for sale at reasonable prices. Many buyers make the mistake of purchasing sheep which are possibly off in type and condition, simply because they are cheap. If the purpose is to work eventually into the breeding of fancy stock the best is none too good. The writer believes it advisable to purchase a small number and secure animals which are of the best type and breeding. As sheep multiply rapidly, it will only be a short time until the flock will be doubled or trebled in numbers.

The thing of most importance is to decide definitely on the breed and then study the best type of that breed thoroughly before purchasing. No more ruinous policy could be followed than to select a flock of sheep off in type and attempt to make a successful show at a fair or exhibition. A few good ones will soon advertise the business until the demand for breeding stock will afford going into it more extensively.

Two plans may be followed in purchasing animals as a foundation for a flock. A ram and the unbred ewes may be purchased, or bred ewes may be secured late in the fall, after the breeding season is over. By following the latter plan the ewes will cost more, but if proper selections are made the buyer will have an opportunity to get in the lambs from the bred ewes some blood of the more noted sires.

For Market Purposes.—In purchasing for market purposes the conditions will be quite different. It should be decided what kind of sheep is in demand. If winter lambs can be disposed of profitably it may be that this business could be followed to advantage. The most important breeds having the early breeding habit are the Merinos, Hampshires, Dorsets, and Tunis. If it is the intention to breed winter lambs some one of these breeds or their grades should be secured. However, the strictly winter or hot-house lamb business requires greater skill than is required in raising early spring lambs by ordinary methods.

No matter what type of lamb is to be produced the sire should be pure-bred and should be of excellent individuality, as an animal of this character will be better able to impress his characteristics on the varying types of ewes selected to form the foundation flock.

Quite satisfactory results can be secured in raising market lambs by using grade mountain ewes, but care should be taken in selecting them. Only those which exhibit maternal qualities such as femininity, vigor and capacity should be selected. Upstanding, rangy ewes should be avoided. Those secured should be low-set and of good length and depth. Broken-mouthed ewes should never be purchased for this purpose, as they can not properly nourish themselves or their lambs. Every precaution should be taken to secure clean, healthy ewes which will by the use of a prepotent sire bring strong, healthy lambs. The best ewe lambs may be retained each year, and in this way the breeding flock may be gradually raised to a high standard.

Period of Usefulness.

The period of service of sheep should be governed by the returns from the flock. As long as the ram is active and continues to get a good percentage of lambs, there is no valid reason for discarding him. The same may be said of the ewes. Tried and proved matrons are always worth more than untried ones.

FIG. 5—A Western North Carolina Hampshire ram in field condition.

The loss of teeth and improperly nourished lambs resulting therefrom is one of the first things which will be noticed. When such a condition arises the ewes should be fattened for market. In a small flock the period of service of the ram will be limited to two or three years, because of inbreeding if he is retained longer. In larger flocks this condition can be remedied by changing him to a new flock of ewes. The ewes themselves should be retained as long as they are sure and profitable breeders. It is not an uncommon thing to get five or six crops of lambs from a single female. Some breeders follow the practice of breeding the females for about four years, after which they are turned with the ram and sold at the close of the breeding season. While these older ewes may take more care if one crop of lambs can be gotten from them, it will enable the purchaser to get an economical start in pure bred sheep.

Selection of Ram.

The ram should be selected with the greatest care. The nearer his individuality is to the recognized standard in type and breed, the more satisfactorily will he overcome any variation in the ewes. This is very important, either with pure-bred females or with the grade flock.

The ram should be selected from a flock of high standard. Conformity to breed type is always important. In the individual, the masculinity, style, vigor, form, quality and wooling should all receive attention. Masculinity should always be evident in a sire, yet coarseness of quality and absence of breeding should not be mistaken for this. The ram should be bold, stylish and vigorous throughout. Style is indicated by the bold carriage of head, and spright, vigorous movements of the animal. A dull, sleepy animal should never be considered for the head of a flock. Such would lead generally to weakness in the lambs. Vigor is shown in the bright eye, the robust frame, the strong full head, the full deep chest and capacious barrel. Good digestive powers such as are indicated here bespeak a rather long period of usefulness.

The form should be square, the ribs well sprung, the body deep, having width and length in proportion. Quality or fineness of structure is a very important factor in considering the purchase of a sire. It is probable that no other point is so hard to explain, yet it is easily seen by the experienced eye. The lines of the animal should be clear cut throughout, the skin clean, pink in color, and the wool bright and lustrous. The plain headed ram with coarse features indicates absence of quality and should be avoided as he is sure to transmit the same characteristics to the offspring.

Selection of Ewes.

The ewes should be selected from a utility standpoint. The show animal which presents the pleasing appearance in the ring will not always do well under field conditions, especially in this State. This type of animal because of the pampered condition will not make the most useful breeder. Ewes which have been reared under natural farm conditions will always be more profitable. This does not mean, however, that the animal of pleasing lines should be disregarded entirely.

The ewe should be strikingly feminine in appearance, yet a weak undersized, over-refined animal should not be mistakenly selected for one having this quality. The masculine appearing female should be avoided. A roomy, capacious ewe should never be passed for one with a tucked-in body, as she will seldom prove to be a satisfactory breeder. A low-set ewe having a long, deep and full body with a good leg of mutton, is the desirable type to breed from for the production of field sheep, as a goodly percentage of vigorous lambs is the main object in view with the general farmer.

It will depend somewhat on the breed selected as to the size and type of the animal, however, in general the points mentioned will be important no matter what the breed may be. Unless the farmer is growing his own supply of females for replenishing the flock, he will likely find opportunities to purchase grade ewes from farmers discontinuing the business, or from some of the local or central stock markets. Every precaution should be taken to get healthy ewes, well wooled, of good form with healthy udders and sound teeth, showing them to be not over two, three, or four years old at most. In the pure-bred business there will be a better opportunity to select choice ewes, although they will cost considerably more than the grades. The breeding flock should be uniform in weight and type, since these qualities transmitted will add greatly to the value of the offspring.

If pure-breds are to be used in starting the flock it will be advisable to buy from parties who are conservative in the claims for their ewes. A great many times fancy prices are paid for pure-bred sheep when better ones could have been procured for probably one-half or two-thirds the amount of money.

Only strong, healthy, capacious ewes of uniform type and wooling should be selected. A broken-down ewe with a scant milk supply is of no value whatever in the flock.

Age to Breed Ram.

As a general thing sheep are bred too early in life for the most satisfactory results. The ram is often bred to a flock of ewes in the fall following birth, a practice which should never be followed except by experienced sheep breeders. Under no circumstances should the ram be bred before he is a year old and better still not until the second fall, when he will be from eighteen to twenty months old. Some breeders will not use a ram heavily even at this age. Ram lambs put into service too early can never reach their natural size nor attain their normal thrift and vigor. While the ram has a very strong reproductive system, early abuse will render him impotent and unprofitable. Proper feeding is far more important during the early stage than the production of a crop of lambs. During an emergency a very early lamb may be used in the fall on a few ewes, but the practice generally leads to excessive service and eventually a very unsatisfactory breeder. The ram is naturally a vigorous animal but early breeding will be sure to cause a much shorter period of usefulness.

Age to Breed Ewe.

A great many breeders follow the practice of breeding lambs at eight and ten months of age, but the most successful flock-masters will allow the females to more nearly approach maturity. With the male the service can be regulated, starting with a few services well distributed, but with the female the burden of maternity is thrust upon her at once. For this reason the extra burden of reproduction should not be allowed to hold in check her natural maturity. If the ewe is not bred until after she is a year old the results will generally be more satisfactory. It will depend somewhat on the size and vigor of ewes just what plan will be best to follow, as size and development should be the principal determining factors when the ewes should be bred. The practice of breeding ewe lambs will steadily and persistently decrease the size of the animals in the flock, which an experienced flock master will not tolerate. The ewe lamb should be fed judiciously and allowed plenty of exercise. By so doing and withholding them from the ram until well matured they will, when placed in the breeding pens, more than make up for the apparent loss.

If the ewe lambs are bred it will cause them to come in heat later and later each season, thus making a crop of lambs which is very undesirable, especially in sections in which the stomach worm is prevalent. The vitality of the ewe will also be prematurely sapped by breeding too young, thereby rendering her much less valuable at maturity.

Care and Management of the Breeding Flock.

The breeding flock demands close attention, yet not more than any other class of breeding animals should have for the most satisfactory results. Regular care, uniform feeding, abundant exercise, and succulent feeds are essential for success. Frequent examinations are advisable to determine if any of the diseases peculiar to sheep are in evidence. Sheep are not heavy feeders, but they should receive their

FIG. 6. A flock of ewes on a farm in the Piedmont section.

rations regularly, especially when they do not have access to pasture. During the summer months after the lambs are weaned, if pasture can be provided little else need be given until just prior to the breeding season, when the ewes should be fed grain somewhat heavier than usual. If ewes are gaining in flesh steadily during the breeding season they conceive more readily and have a better opportunity to care for the fœtus through the extra flesh which they carry. After the breeding season is over pastures will soon begin to deteriorate. If corn silage can be had it will be valuable for keeping the ewes in that vigorous condition which fits them for the lambing season. Dry feeds at this time are undesirable, especially if they are inclined to be too carbonaceous in character.

If good roughages can be obtained, such as cowpea, clover or oat hay, the concentrates may be fed rather sparingly, however, if the roughage is of poor quality more and better concentrates should be given. The English method is to supply roots during the winter season and these, with the dry roughages given, constitute largely the daily ration. However, in this country roots are not extensively grown on account of the extra labor and cost, but corn silage may be very successfully substituted.

In the early spring preparation must be made for the lambing season. Feeds of a nitrogenous character and cooling in effect should be given at this time. Dry fattening feeds should be avoided, and those of a succulent character should be given instead largely. The ewes should not be closely coralled, but should be given plenty of range, which will tend to keep the system in a strong healthy condition.

The ewe barn should be large and well ventilated. If these things are provided and the health of the flock is looked after properly, there need be little cause for not making the sheep business a success.

Period of Gestation and Heat.

The period of gestation is about one hundred and fifty days or five months approximately. The time may vary considerably, but on the average the above is correct.

Normally ewes breed during the fall months and lamb in the spring. Some breeds, however, will conceive much earlier so that the lambs come during the winter season. During the breeding season the ewe comes in heat every three weeks and remains in this condition for three to four days.

Breeding.

The breeding season usually begins in July and continues until late in the fall. The Dorsets, Merinos, Tunis and Hampshires breed earlier in the season than most other breeds. The Shropshire and Southdown, for example, conceive somewhat later and the long wool breeds still later, the latter lambing usually in March or April. Ordinarily under the conditions in this State, the lambs can be made to come quite early in the spring. This is most advisable for warding off the ravages of the stomach worm.

Two practices may be followed in breeding the ewes. The ram may be put with the flock and allowed to run with them as practiced on the ranges. The best plan, however, is to keep him coralled during the day and turn him with the ewes during the evening or early morning. He will remain more active by handling in this way, and will care for a larger flock of ewes. The time of mating and the cross made will depend on the use or disposition that is to be made of the offspring.

Flushing Ewes.

It is a practice among some sheepmen to have the ewes in a rapidly gaining condition during the breeding season. Practice has demonstrated that ewes in this condition conceive more readily and drop a greater number of twins than when in a normal or run down condition. After the breeding season they should be kept in good flesh, but should not be made excessively fat. By so doing they will be better fitted to go through the winter preparatory to lambing and caring for their offspring. Flushing on grain gives them new life and vigor which is important in nourishing a strong, healthy lamb.

Care of Pregnant Ewes.

One of the common faults in caring for pregnant ewes is to feed them either too sparingly or too heavily without sufficient exercise to foster the best bodily functions for the reproduction of strong, vigorous lambs. As far as possible natural conditions should be provided. The ewe barn should be light and airy and be sufficiently large to accommodate the flock without crowding. They should be sheltered especially from cold, penetrating winds, rain or snow.

Care should be taken to avoid misjudgment as to the condition of a ewe. With the long coat of wool it is not so easy to determine a run-down condition as in other farm animals. Ewes should come to the lambing period in the pink of condition, yet not burdened with fat. They should carry just enough flesh to insure the stimulation of a good milk flow on which depends the success of the lamb crop. Thin ewes make very poor mothers, often disowning their lambs. A condition of this kind is sure to result in failure and condemnation of sheep raising.

Range ewes having ample exercise seldom if ever give birth to weak lambs if they have been fed properly. Small, cramped barns and lots, lack of exercise and heavy feeding without regular exercise are the bane of the sheep industry.

Care of Ewes After Lambing.

At the approach of the lambing season it is a good plan to examine the condition of the ewes to see that they are thrifty and to determine if their udders are in good condition. The small locks of wool should be trimmed away from the teats to avoid hair balls which sometimes form from these locks in the stomach of the lambs. After the lambs show their ability to find the teats without aid the success of raising them is well in progress. For a time after birth they should be confined with the mother in a small pen to prevent them from getting lost in the flock. After a few days, however, they can be turned in the lots or pasture with the flock.

For a day or so after lambing the ewe will need little to eat except some pure water and bright clean hay. As the lamb develops and grows stronger the mother may be fed a light concentrated ration. Wheat bran is excellent for this purpose and somewhat later some crushed corn, oil meal, linseed meal or cottonseed meal may be added. For the ordinary sized ewe a pound per day and for very large ewes from a pound and one-half to two pounds of grain per day is ample for a large milk flow. If this is supplemented liberally with pasturage or silage the quantity may be reduced. The lambs should be kept growing as rapidly as possible without causing digestive troubles. Early lambs, if thrifty and fed properly, may be pushed and placed on the market before warm weather and thus the ravages of parasites will be avoided. If they are to be retained on the farm they should be weaned at three to four months of age, which will make it possible to put them on clean pasture away from the ewes before they have become infected. This will be of great practical aid in carrying the lambs through the summer without becoming infested with parasites. Grazing on annual crops and a change of pasture are the best practical means known of overcoming this trouble. Tobacco dust and salt are used as a preventive or for the destruction of the worms after the sheep are infected. The use of gasoline is also recommended for this purpose. Medicated salt has been used with considerable satisfaction in treating stomach worms. A box containing some worm preventive should be kept in the lots or pasture where the sheep and lambs can have free access to it.

When the lambs are weaned the udders of the ewes should be looked after carefully until the milk flow is diverted. The ewes may then be turned on pasture, and there gain the larger part of their livelihood until breeding time in the fall.

Care of Young Lambs.

The sheep barns and other equipment should be in good repair before the lambing season begins. This is a critical stage with the flock and too much care and forethought can not be taken for the best results.

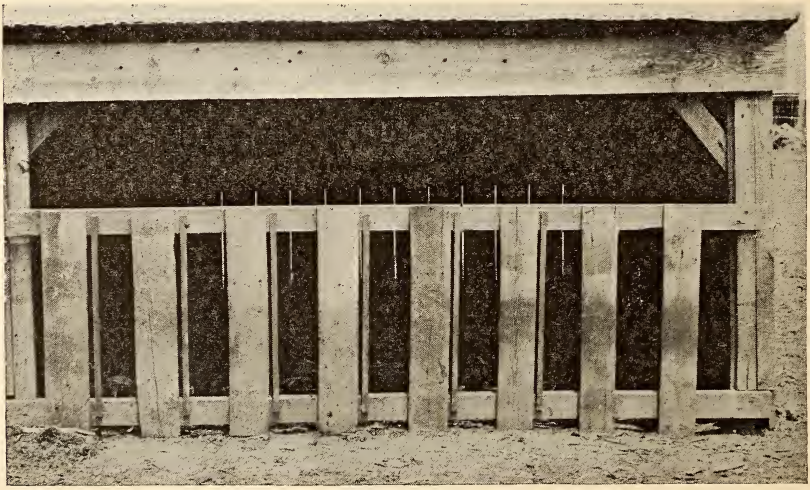

FIG. 7—An improvised lamb creep.

The ewes heavier in lamb should be separated from the remainder of the flock, so that the closest watch can be kept of the arrival of lambs. In this way any assistance needed in lambing may be given and if the lambs are small and weak they should be thoroughly dried, put in a comfortable place, and given every assistance in getting their first milk. Lambs which are withheld from their first nourishment for any reason stand little chance to survive and make thrifty specimens. Ewes which disown lambs should be given a separate place where they will have an opportunity to get acquainted and possibly later they will claim their young. In the event they should not, after persistent attempts, it will be necessary to raise them by hand. Milk from the cow should be used and diluted about one-third with water. The utensils for feeding should be kept scrupulously clean to avoid scouring.

After the lambs once get well started and take the milk regularly, the feed of the ewe can be increased gradually until at the end of three or four weeks she should receive her full ration. The lambs should be induced to eat as early as possible to avoid a severe shock at weaning time. Ordinarily it will only be a very few days after birth until they will begin to eat grain and nibble at bright clean hay. It is advisable to build a creep in which the lambs can go, but to which the ewes will not have access. This is the English method, and there is no doubt regarding the art which they possess in sheep husbandry.

Weaning Lambs.

The lambs should be weaned when three to four months old. If they are properly fed in a creep where they alone can have access to grain and forage, there will be no further trouble at weaning time. For a time after the lambs are weaned the mothers should be given non-milk producing feeds. The legumes and green grazing crops, especially should be withheld. By withholding these feeds and allowing the lambs to suckle several times there should be no trouble with the udders unless it is with a very heavy milking ewe. If a lamb is allowed to return to a heavy milker she should first be milked out before the lamb is allowed to gorge itself and bring on digestive troubles.

Lambs which are to be sent to the market early in the season need not be weaned, but allowed to get every benefit of the mother's milk which will, when it is properly supplemented with grain and forage, give the lambs a full, plump appearance.

Winter and Early Spring Lambs.

There is no doubt but what a large number of farmers in this State could profit by buying a flock of grade ewes, cross them on a good pure-bred mutton ram and market the lambs during the early spring months. A good grade of ewes may be obtained from the mountains or from Chatham or surrounding counties at very reasonable prices. While the supply is limited, especially from the latter source, if more attention were given to sheep raising it would not be long until the supply of breeding females would be materially increased in numbers and in quality. The local markets throughout the State will handle a goodly number of lambs for spring trade. By having the ewes lamb the latter part of February or early in March the lambs can be placed on the market in May, June, and July usually at remunerative prices. The best ewe lambs may be retained and given special attention for the purpose of grading up the ewe flock.

The grade ewes necessary for producing spring lambs can usually be purchased for three to five dollars each, depending on their size, breeding and condition. Quite often the lambs will the first year more than pay for the original cost of the ewes and their keep, saying nothing of the value of the wool clip. If the ewes are extra good, they can be used for two or three seasons, after which the higher grade ewe lambs from the pure-bred ram will be coming into active service.

The winter lamb is a specialized product and the lambs coming in the middle of winter require much extra care and expense which is not necessary in raising the early spring lamb. Liberal prices must be received for winter lambs to offset the extra cost of production; and usually the farmers of this State are not in a position to handle a specialized business of this kind. The winter or hot-house lamb is also a product of ewes specially adapted for early breeding, and it is not a usual thing for the mongrel ewes of the State to form this very early breeding habit. Until better foundation stock is secured and more specialized sheep farming is followed the writer believes the production of early spring lambs to be the most profitable line of sheep raising.

FIG. 8—Grade Shropshire lambs produced from native ewes crossed on a pure bred Shropshire ram.

Selection of Feeders.

The selection of feeding sheep at the central markets or from farms for the purpose of fattening for a later market has not been a common practice in this State, although in Virginia, Kentucky, and some other southern States this plan is followed to a limited extent. In the corn belt States large numbers of sheep are so fattened, often with profitable results. On the western ranges large central fattening plants are maintained, where sheep are fattened largely on alfalfa and corn.

This is a business which it pays to investigate thoroughly before going into it on a large scale. For the beginner it would be far better to maintain a few good grade ewes, cross them on a pure bred mutton ram and dispose of the lambs in the early spring, retaining the better females to build up the flock. Experience gained in this way would be very beneficial in getting into the sheep business on a larger scale. For the North Carolina farmer the writer believes it a better and a more conservative plan to keep a small farm flock instead of undertaking to buy feeders for subsequent marketing.

In the selection of feeders only good thrifty specimens should be purchased. They should be from good mutton stock, clear of eye and clean in fleece. A healthy sheep has a pink skin and a bright, lustrous wool. The unhealthy one has a white pale skin, a dead fleece, and the animal lacks in life and in vigor. The form of the feeder should be blocky, low-set, capacious, and not too heavy of wool, which often indicates a light-weight unprofitable feeder. These remarks will apply both to lambs and to wethers. Any one anticipating going into this phase of the sheep business should study thoroughly the demand for the product, the market condition and the grain feed and forage produced on the farm. If plenty of good, clean forage is available at a reasonable price this business may be made a profitable one. It is very likely, however, that this plan of sheep farming will not develop rapidly since the supply of desirable feeders is very small, owing to the small number of sheep of all kinds produced in the State.

Marking.

There are various methods in use for marking pure-bred sheep. The button or band in the ear bearing the flock number, the breeder's initials and the registry number of the recording association are quite generally used. The objection to this method is that the buttons or bands are often pulled out and the identity of the sheep lost.

The notch system, used more frequently in hogs, is sometimes used, but the ear of the sheep being small the marking may disfigure it which makes this system to some very objectionable.

Paint used on the wool is injurious and the identity sooner or later becomes lost through fading or shearing of the flock. This method is sometimes used to mark ewes during the breeding season to determine the time when they were bred.

The tattoo marker is the most satisfactory. This consists of a hand-pincer with a frame in the jaws of which may be inserted needles from which the initials of the breeder may be made. These needles are covered with a special kind of India or indelible ink, either white or black, which is impressed in the ear. The pincers should be properly adjusted, else the initials will not be clear and perfect. In England this method of marking is used extensively.

Shearing and Tagging.

Usually sheep are sheared once during the year. Some few breeders practice shearing both in the spring and early fall, but by so doing the value of the staple is decreased, owing to the shortness of the fiber. Sheep should be relieved of their wool in the spring as soon as weather conditions will permit. If the ewes lamb early it is better to leave the wool on until after lambing; however, a careful flockmaster can shear them earlier without doing them injury. The wool should be clipped close and uniformly, either with hand shears or with a machine. The latter can be used by the beginner to better advantage, however, a large number of sheep, forty to fifty, can be sheared by hand in one day if one is expert at the business.

The shearing should be done in a light, clean place, preferably on a smooth wooden platform, or on a canvas cloth to keep the fleece clean. Sheep should never be tied or held by the horns while being sheared. They should be turned upon the buttocks with the head and shoulders resting against the shearer. The wool should be opened on the belly and clipped away carefully, keeping the skin drawn tightly at all times. By so doing there will be no danger of cutting the skin.

FIG. 9—Showing position to hold a sheep to keep the skin drawn tightly while shearing.

After the wool is removed all the filth and tags should be removed. The fleece is then rolled up, the loose fibers and ends being turned toward the center, leaving the cut side of the fiber out. If the wool is carefully clipped, wrapped and tied it will add considerably to its appearance and value. Wool should never be tied with anything except the wool itself, or with regular fleece twine, the best of which is made from paper. This latter being light in weight does not add to the weight of the wool. Binder or sisal twine of any kind should never be used, as the fibers of the twine become mixed with the wool and detract from its value. Sometimes a loss of as much as four or five cents per pound in the raw wool is sustained from this cause. Wool coming from certain territories is at times greatly discriminated against because of this condition.

Tagging or removing the particles of manure which collect in the wool should be done often to prevent sheep from getting in a filthy condition. Even when properly docked they will often accumulate droppings in the wool which become very offensive and disagreeable. By the use of the hand shears a large number of sheep may be gone over in a short time much to their comfort and appearance.

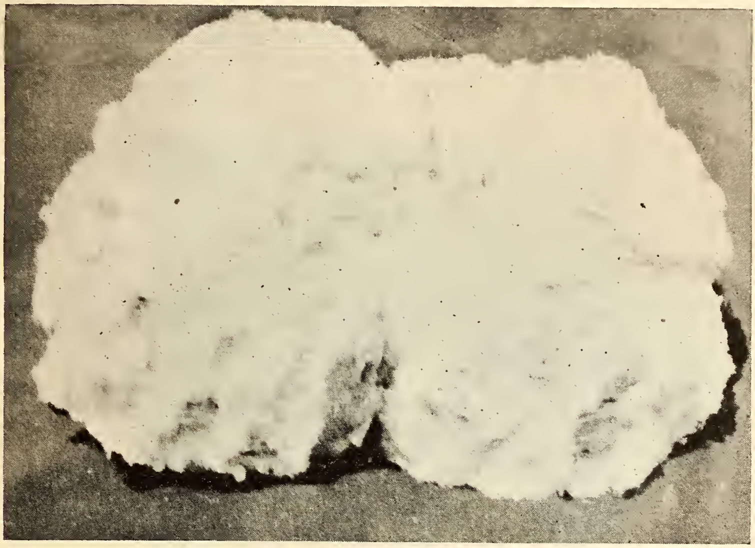

FIG. 10—A fleece properly tied without the use of binder or sisal twine.

Keeping the Flock Healthy.

In keeping the flock healthy, the feeding can not be too much emphasized. Sheep will subsist largely on rough feed, such as leguminous hays and roots. Too much concentrated feed, especially for sheep not in the habit of getting it, may cause serious digestive troubles. Native sheep should be brought gradually to their grain ration, as sudden increases are very likely to cause loss in the flock. Lambs especially should be carefully handled to prevent digestive troubles. Although they should be pushed for market they should be brought gradually to their full ration.

The pastures should be changed often to prevent infection from stomach worms and succulent feed should be supplied as much of the time as possible. During the winter corn silage and roots should take the place of summer pasture.

Dead carcasses should be burned, as they often harbor parasites which pass part of their life in other animals which may visit these places and spread or prolong the trouble. Sheep brought from other flocks should be examined carefully for disease and parasites, as they are likely to infect the entire farm flock if they are diseased. If the ewe lambs retained to replenish the flock have been supplied with a rotation of pasture where infected sheep have not been allowed for at least one year or since cultivation for seeding, a healthy flock will be assured.

Dipping the Farm Flock.

The dipping tank can not only be used for sheep but for hogs and young calves as well, so that the entire outlay need not be charged up against the sheep. Dipping is especially valuable in overcoming the ravages of scab, lice and ticks, but it will also prove beneficial in preventing eye, nose and mouth troubles. If regular dipping is practiced it will not only prevent to a large extent may of the ravages common to sheep, but it will maintain the flock in a much better state of general healthfulness.

Fig. 11—The Station farm dipping tank in use.

There are a number of proprietary dips on the market which can be used successfully and at a moderate cost. Standard dips of this kind are generally used in the proportion of one part of dip to forty parts of water, making a two and one-half per cent solution. The best and most effective time to dip sheep is in the spring, about ten days after shearing. It will take much less of the solution and be far more effective. Dipped in this way the sheep can be put through the tank very rapidly, while if they are dipped for scab or while the wool is on they should be immersed several times and held under excepting the head from one and one-half to two minutes. In case of sheep scab the scabs should all be loosened, so that the dip will thoroughly penetrate the exposed parts.

The dipping tank can be made of wood, galvanized iron, or concrete. The concrete tank will last indefinitely and is the most economical type in the end. The galvanized tank can be purchased on the market at a moderate cast.

In the actual construction of a dipping tank the aim should be to provide for efficient dipping and still not have the tank so large as to require an excessive amount of dip. If properly constructed the saving of dip will prove to be an item during the season.

The ordinary galvanized iron tank is the one in most common use, but it is not as lasting as a tank built of brick and then cemented, or the solid concrete vat built in a mould or form. This latter tank will cost somewhat more, but will last for a lifetime, and there will be no danger of bulging or leaking if the masonry work has been properly done. A tank ten feet long at the top, four feet long at the bottom, twenty inches wide at the top and eight inches wide at the bottom, and four one one-half feet deep will answer every purpose. The tank should be set four to eight inches above the ground to keep out surface drainage and filth, the admission of which would weaken the disinfectant, and make it very disagreeable in dipping sheep. All necessary equipment for dipping should be located convenient to the yards or lots where the majority of the stock is kept. This will admit of more frequent dipping and at much less trouble and expense. The animal should be dropped buttock first directly into the disinfecting solution. A draining floor should be provided. If sheep are dipped with the wool on they will carry considerable dip from the tank and make the operation more expensive. By building a fence around the drain leading back into the tank the sheep can be held there for a short time and thus save much of the liquid carried out in the wool. Where large flocks are being dipped it will be advantageous to divide the draining pen into two equal parts, having a swinging gate at the end of the partition next to the outlet end of the tank. This gate can be swung to either side, thus closing one of the pens and allowing one side to be filled with sheep to drain while the other side is being filled. By alternating in this way much greater headway can be made.

Castration and Docking.

Both of these operations should be performed early in the life of the lamb, as it will not only avoid pain but the wounds will heal quicker. When the lambs get started after these operations there is nothing to prevent their going on rapidly to maturity. It is necessary to dock early in order to avoid the filthy condition in which undocked lambs usually get. It is customary to do the docking first. It may be done most any time, however, after the lambs get well started to growing.

Several methods of docking are in use. The simplest one is to draw the skin back close to the root of the tail, tie a string tightly around and sever the tail from the under side with an ordinary knife just below the portion encircled by the string, and where the skin has been drawn back. Another method is to use an ordinary mallet and chisel, severing the tail on a block. With this method also it is best to stop the blood flow by the use of a string just above the part severed or by the use of a searing iron.

The safest plan is to use a pair of docking pincers or a docking iron, which can be procured from a sheep supply house, or it can be made by any blacksmith in an emergency. The pincers or docking iron are heated red hot, the tail is run through a hole in a board and then severed by the pincers or iron just below the board which partially protects the remaining portion of the member from the heat of the instrument. By this method there is no bleeding and consequently no danger whatever, whereas by other methods a lamb sometimes bleeds profusely. If for any reason a mature sheep is to be docked, the docking pincers or searing iron should be used. Some good disinfectant material, such as that used in dipping, should be applied after the tail is severed. In warm weather every precaution should be taken to see that the stump tail does not become infested with maggots.

The castration of lambs should likewise be performed early. The operation is simple. The lower end of the scrotum is cut off, the testicles forced down through the openings, after which they are pulled out with a portion of the cords adhering. After the operation a mixture of lard and turpentine or other good disinfectants should be applied to the wound. In castrating old rams the safest way is to use the hot docking iron, severing the entire portion of the scrotum containing the testicles. By this method the arteries are seared by the heat and there is no danger of excessive bleeding. In both castration and docking great care should be taken to use tools which are thoroughly disinfected before use.

Constipation.

Constipation is usually the result of injudicious feeding or the lack of succulence in the ration. Roots, silage or oil meal are indispensable in preventing this trouble. This trouble in lambs is generally brought on by improper feeding of the ewe. Rations which are inclined to be heating or excessively fattening should be avoided. These troubles are likely to come on during the winter season, when succulent feeds are not available and when heavier grain feeding is practiced. With lambs, constipation may be very detrimental and cause heavy losses in the flock. The symptoms of constipation are dullness, sleepiness and loss of appetite. A rectal injection of raw linseed oil or soapy water will usually relieve the condition. If the lambs are affected the ration of the ewe should be corrected, and the lamb should receive a dose of castor or linseed oil.

Stomach Worms.

One of the most dreaded diseases of the sheep farmer is the stomach worm, which is very fatal to young lambs. Fortunately the stomach worm thrives only during warm weather and under rather moist soil conditions. This fact can be used to advantage by having the lambs come early and sell them before the stomach worm has a chance to thrive. This is one important argument in favor of the early lamb in this State where worms will likely give trouble if proper management and preventives are not used. While these worms are common in mature sheep they do not cause the great emaciation and high mortality here as in young lambs. The worms are matured in the sheep, from which the eggs produced finally pass and are scattered over the pasture. Afterwards they hatch and find their way into the stomach of the lambs. Here they develop and generally cause serious trouble.

One of the most practical methods of overcoming this pest is to have the lambs come early. They should then be weaned before the advent of warm weather, during which the worms will begin to develop. After the lambs are taken from the ewes they should be placed on a non-infected pasture, be well fed and kept until marketed. Frequent change of pasture, even during this short stage of development is effective.

Care of Feet.

Sheep kept on rough rocky soil ordinarily keep their feet in good condition. However, on the arable farm where there is nothing to cause a natural wearing, the hoof should be kept trimmed to prevent deformed feet. If the natural wear does not keep the hoof in good condition it will be well to trim the feet before going to pasture in the spring. The hoof can be very greatly softened by allowing the sheep to run through damp grass. When worked on in this condition they will cut much easier than otherwise. The hoof should be kept short and straight, to prevent a crooked foot or leg.

One of the most common diseases of the foot is known as foot-rot or foot-scald. Any indication of this trouble should be looked after at once. All the diseased parts should be kept cut away and exposed to the action of a disinfecting solution. This disease in the simpler form can be treated quite successfully by a solution of some coal-tar disinfectant or with carbolic acid. When the disease has become deep-seated, however, more careful and persistent measures should be used. The diseased parts should be thoroughly exposed by frequently trimming away all such tissue and disinfected with a strong solution of copper sulphate. If the parts have been cut away to any extent the foot should be bound up and the animal kept in a dry, clean place until a cure is effected. Wing recommends the use of a trough, about ten feet long, six inches wide at the bottom, twelve inches wide at the top and six inches deep. This is placed in the passage-way from the barn to the lot in such a way that the sheep are compelled to walk through it in going to and from the barn. The trough should be partly filled with whitewash to which is added copper sulphate solution in liberal amounts. This is an effective remedy, especially if the disease is discovered and treated in the incipient stage.

Caked Udder.

Caked udder is likely to give trouble in a heavy milking flock of ewes if proper care is not given. This may happen early after the birth of the lamb by too rapid forcing of the ewe or at weaning time when the feed of the ewe is not properly changed or reduced and the excess of milk drawn from the udder. For several days after weaning the ewes should be kept milked out and by properly reducing the feed the milk flow can be checked. In a bad case of caked udder the ewe should be well sheltered, the udder bathed in hot salt water, and a mixture of lard and turpentine applied.

In case of garget of the udder, which is sometimes brought on by cold and exposure, purgatives should be given, the udder bathed, and camphorated oil or lard and turpentine applied. If an abscess forms it should be opened and kept well washed out with a good disinfectant, such as a weak solution of carbolic acid or creolin.

Bloat.

Sheep should never be allowed to pasture on clover, alfalfa, or rape when they are especially hungry. They should first be given dry roughage and then be turned on the pasture, but only for a short time each day until they become accustomed to the change. If precaution is not taken in this matter the sheepman will likely have a bad case of bloat on his hands.

To relieve this trouble tap the stomach on the left side at the point where the distention is greatest, which will be midway between the backbone, the point of the hip bone, and the last rib. A pocket knife can be used for the purpose, but a trocar is best. This instrument not only makes the incision but the cannula or sheath keeps it open in such a way that the gas can readily escape.

Purgatives should be given to otherwise relieve the congested condition of the animal. Linseed oil is very desirable for this purpose. In an acute attack of bloat three drams of hyposulphite of soda and one dram of ginger mixed in water will usually prove very helpful.